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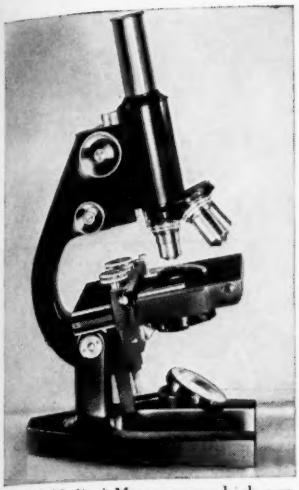

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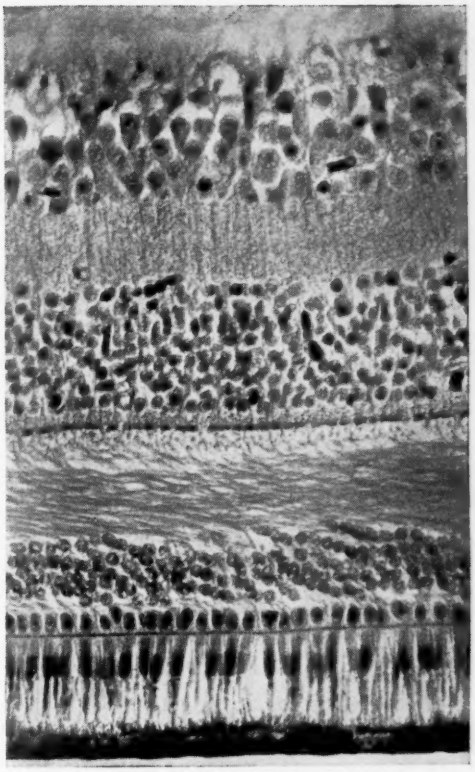

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PHYTOPATHOLOGY

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THE HOST RANGE OF THE SOUTHERN CELERY-MOSAIC VIRUS

F. L. WELLMAN

(Accepted for publication September 29, 1934)

Farmers in certain winter truck-growing regions of Florida have long been troubled with a serious mosaic disease of celery. The writer (8) described the virus causing this mosaic, found it was new, and named it *Celery virus 1.* The exact geographical distribution of the virus is not yet known, though Doolittle and Wellman (2) have reported celery with the same mosaic symptoms from Florida, Ohio, New York, Wisconsin, and California. The writer (9) also has reported it from Cuba. Two investigators, Kunkel (5) and Cook (1), have reported virus-diseased Commelina plants from other tropical regions.[1]

Doolittle (*cf.* Doolittle and Wellman (2)) was the first to find that the monocotyledonous weed, *Commelina nudiflora* L., was a common host of the virus. The writer has since then reported (8) a fairly large host range, certain portions of which further proved the distinctive properties of *Celery virus 1.* Encouraged by such knowledge, additional inoculations were attempted on both dicotyledonous and monocotyledonous plants. Proof of infection and study of the diseases produced has been secured on several species of Gramineae (9) and 2 species of Musa (10). In connection with the studies on field dissemination of the virus (11) careful observations were made on new weed and cultivated hosts with apparent virus infections in nature and these were further checked experimentally. In work upon methods to control the virus much attention has been given to eradication measures, some preliminary results of which have been reported (7). As the control problem has advanced it has become important to know more fully the commonly affected weeds and ornamentals. In the course of these studies it has become evident that the virus attacks a much larger group of economically important hosts than was at first considered likely. For all these reasons special attention was given to this problem, and this paper reports the results of the investigations.

[1] Carter has stated very recently (Carter, W. Mechanical transmission of two viruses to pineapple. Phytopath. **25**: 10. 1935.) that "Mosaic of *Commelina nudiflora* in Hawaii is apparently identical with that described from Florida."

MATERIALS AND METHODS

The source of virus (*Celery virus 1*) material used in these studies was exactly the same as that originally described by the writer (8). All aphids, *Aphis gossypii* Glover, used for inoculations in these studies were from colonies maintained by S. P. Doolittle of the Bureau of Plant Industry. The specific names of experimental plants were determined with as great care as possible and are included in the complete host range reported (Table 5 (p. 394)) and the list of apparently nonsusceptible hosts (p. 399). The vegetable and ornamental plants were all from seeds of named varieties from reputable seedsmen. The weeds were largely from around vegetable fields in Florida, and the specificity of susceptible species, with the exception of the Phytolaccas and *Cucumis anguria,* were determined by S. F. Blake of the Bureau of Plant Industry. In the miscellaneous plant list, seeds of small grains and teosinté were obtained through A. G. Johnson of the Bureau of Plant Industry. With the exception of a few packets purchased from seedsmen, all corn, or maize, seed was secured through J. G. Dickson of the Bureau of Plant Industry and University of Wisconsin. Bulbs of flowering ornamentals were obtained through Freeman Weiss of the Bureau of Plant Industry. The solanaceous plants used were grown from seeds supplied by F. O. Holmes of the Rockefeller Institute for Medical Research, except the Daturas and Broadleaf tobacco which were from S. P. Doolittle.

Whereas the majority of the inoculations of plants were made in the greenhouse at Sanford, Florida, a few of the reported tests were carried on in greenhouses at Arlington Experiment Farm, Rosslyn, Virginia, in New York and also in Wisconsin (8) while the writer was determining the identity of *Celery virus 1.* With the exception of a few hosts, inoculation studies were repeated more than once and under varied conditions.

Original plants of *Commelina nudiflora* were kept for source of virus. Aphids were colonized on these and transferred to young White Spine cucumber, *Cucumis sativus,* and Golden Self Blanching celery, *Apium graveolens,* plants. On the day the vein-clearing symptoms became severe, leaves with these symptoms were removed, chopped up, ground to a pulp in previously boiled porcelain mortars, and the juice squeezed out through new cheesecloth into boiled glass jars. Bits of new cheesecloth were wetted with these viruliferous juices and were rubbed over the washed leaves of plants to be tested for susceptibility to the virus. Every series of plants inoculated was rubbed with a separate piece of juice-moistened cloth, and once a piece was used for inoculation it was discarded. Hands were washed with soap and water and dried between inoculating each set of plants. In 1 to 5 minutes after inoculation, excess of juice that had been rubbed

onto the plants was washed off, and in most cases the plants were protected from exposure to severe sunlight for about 18 hours.

Viruliferous aphids were secured in the following manner: Diseased cucumber and celery plants were placed under cheesecloth cages. Leaflets with virus-free aphids from colonies maintained on healthy cucumber and celery plants were transferred to the diseased plants and the aphids were allowed to feed on virus-affected leaves from 5 to 14 days. It was early found that, besides the tedium involved, aphids transferred with camel hair brushes were not consistent in their ability to transmit the virus. If allowed to crawl away from diseased leaf pieces onto healthy foliage, however, infection occurred more generally. In consequence, bits of diseased leaves, having 15 to 40 undisturbed aphids on them, were clipped from colonized diseased plants and fastened in the foliage of the plant to be tested for susceptibility. In the case of banana plants from 75 to 150 aphids were used (10) to transmit the virus.

Plants infested with viruliferous aphids were kept in cheesecloth cages for 5 to 10 days, then sprayed with aphicides a number of times, and finally removed from the cages when all aphids were killed. Plants inoculated by the leaf-rubbing method also were sprayed at intervals and all inoculated plants were watched 2 months for disease production before being discarded. Precautions were taken to insure certainty that leaf injuries, sustained from leaf-rubbing methods, or nonviruliferous aphid-feeding marks, were not mistaken for primary lesions. From 5 to 55 plants of every inoculation series were always kept untouched, except that they were sprayed, for control purposes. Occasionally, aphids escaped from inoculation cages and in a few cases a virus infection appeared in the control plants as well as in the inoculated series. On such occasions series connected with these occurrences were discarded, all diseased and healthy plants, whether they had been inoculated or not, were destroyed and the inoculations were repeated on plant material obtained from an absolutely new source of seedlings.

With a few exceptions all hosts that became diseased after inoculation were tested by juice or aphid transmission to celery and cucumber seedlings for the presence of the virus. In most of these cases the originally inoculated leaves were labelled and their juices were tested separately from the other leaves, which either remained symptomless or showed evidence of systemic invasion. While not every plant that gave negative results to celery-virus inoculation was tested, a few plants of a large majority of the apparently virus-free species were tested.

Parallel with the greenhouse host-range experiments, field observations were conducted to corroborate these studies, and to gain knowledge of dissemination of this virus (11) and its natural occurrence. Diseased foliage

from any ornamental, weed, or vegetable plant found with symptoms of virus attack in the field was brought in and tested for presence of *Celery virus 1*. This phase of the investigations included diseased material on many hosts from widely separated regions in Florida. After positive results from tests of naturally diseased plants had been obtained the first time, a second lot of material was secured and tests repeated.

EXPERIMENTAL RESULTS

Vegetable Crops Diseased by the Celery Virus

The celery virus was described by the writer (8) from severely affected celery. Before the virus had been described, Doolittle and Wellman (2) had determined that celery plants could serve as source of inoculum to produce virus infection of tomato, *Physalis pubescens* (husk tomato) and cucumber. In addition to the above vegetables the writer found (8) that the red garden beet, Tabasco pepper, sweet peppers, Cocozelle squash, summer crookneck squash, muskmelon, and watermelon were susceptible vegetable-crop hosts, and later reported (9) that sweet corn and sweet potatoes were likewise susceptible to the virus. In a recent paper (11) the writer has described natural occurrence and dissemination of this virus in fields of Golden Self Blanching celery, Golden Summer Crookneck squash, Cocozelle squash, California Wonder pepper, World Beater pepper, and sweet corn.

In the accompanying table (Table 1) is a list of all vegetable crops that have proved susceptible to *Celery virus 1* under conditions of these investigations. The common English names have been used with numbers indicating the Latin binomials designating their species (Table 5). A great many vegetables tested for susceptibility proved apparently immune from this virus, as may be noted by reference to the list (p. 399) appended at the close of the presentation of experimental results in this paper.

One of the surprising features of the host-range studies has been the fact that so many vegetable crops are susceptible to the celery virus. In some cases the symptoms of this virus attack differ so greatly in separate species that it is believed of interest, as well as of importance, to discuss a few such reactions in detail on given crops.

Celery: The southern celery mosaic (*cf.* (8) (2)) disease is most notable in the fields when plants are approaching the proper size for harvest. The rows appear uneven and present a ragged appearance to the field, especially around the edges, though it may extend throughout the field. Diseased plants are stunted. They have a badly mottled and yellowish aspect, leaflets are twisted and flattened towards the ground, and the petioles and leaf rachises are often darkened throughout; though sometimes scattered buff, almost salmon color, water-soaked spots and sunken streaks appear on them. The markedly stunted appearance of plants is due somewhat to

TABLE 1.—*Results of studies on vegetable crops found susceptible to the southern celery-mosaic virus, including symptoms and field occurrence (Compare with Table 5 for species names, number of plants used, and recovery of virus)*

No.[a]	Vegetable Crop	Inoculation methods	Symptoms[b]	Occurrence in field
21	Beet (Red Garden)	Aphid, rubbing	LR–M–*M*–S	+
35	Carrot	" "	.....N–M–Y	+
42	Celeriac	Rubbing	LO–S–M–N–Y–D	
39	Celery (Golden types)	Aphid, rubbing	LO–S–M–N–Y–D	+
40	Celery (Flavoring)	Rubbing	LO–S–M–Y	
41	Celery (Green Pascal)	Aphid, rubbing	LO–S–M–N–Y–D	+
22	Chard, Swiss	Rubbing	LN–M–*M*	+
2	Corn, Sweet	Aphid[c]	LY–*S*–S–M–N	+
83	Cucumber	Aphid, rubbing	LN–M–S–N	+
36	Dill	"	.....S–Y	
55	Eggplant	" "	LN–M–*M*	+
37	Fennel	"	.....S–Y	
59	Groundcherry, Common	" "	.....M–S–D	+
58	Groundcherry, Strawberry	Rubbing	.....M–S	
84	Muskmelon	"	LN–M–S–N	
26	New Zealand Spinach	Aphid, rubbing	LW–M–*M*	+
16	Onion	Aphid[c]	.....M–S–D	+
38	Parsley	Aphid, rubbing	LY–M–N–Y–D	+
43	Parsnip	Rubbing	LO–M–N–Y	
66	Pepper, Sweet	Aphid, rubbing	LN–M–N–S	+
77	Pumpkin	" "	LW–M–S–N–D	+
23	Spinach	" "	LN–N–Y–M	+
79	Squash (Cocozelle)	" "	LN–M–D–Y–S–N	+
78	Squash (Golden Summer Crookneck)	" "	LN–M–D–Y–S–N	+
80	Squash (Hubbard)	Rubbing	LD–M–D–S	
47	Sweet Potato	Aphid[c]	.....M–D–S	+
56	Tomato	Aphid, rubbing	LD–Y–M	+
30	Turnip[d]	Rubbing[e]	LN	
81	Watermelon[f]	Aphid, rubbing	LN–M–Y–S–N	+[f]

[a] These numbers refer to host species identically numbered in table 5.

[b] L refers to primary lesions: D-diffuse, N-necrotic, O-none developed, R-reddish, W-whitish, Y-yellowish, ...-uncertain of production. Other single letters refer to systemic symptoms: D-distortion, M-mottling, *M-masking*, N-necrosis, S-stunting, *S-stripe*, Y-yellowing.

[c] Leaf-rubbing methods failed to produce infection.

[d] Credit should be given at this point to T. J. Grant, who, while in a collaborator's capacity (8), first observed independently primary lesions caused by the celery virus on turnip leaves. The writer secured the results cited here on tests involving one variety in Florida.

[e] No tests with aphid inoculation methods produced infection.

[f] Since preparing these data for publication naturally infected volunteer watermelon plants have been observed in a field near Sanford, Florida.

shortened leaf petioles and rachises, but in greatest measure to a downward curvature of those foliage parts. The dark or streaked petioles and rachises are at first brittle and easily broken; later, becoming more withered and necrotic and finally decaying.

Inoculation studies have shown that the first symptom of southern celery mosaic on young leaves is a faint vein-clearing pattern, which occurs under the most favorable greenhouse conditions in about 6 days, although it may take 10 to 40 days for it to appear in the field. The vein-clearing pattern on leaves usually changes in about 10 days to a brilliant yellow mottling that, about a month later, is not so marked. Secondary systemic symptoms in older leaves result in yellowish oak-leaf patterns which in some cases take the form of continuous zig-zag bands across the leaf lamina, and in other cases are markedly irregular and may break up into chlorotic blotches and spots.

Sweet Pepper: Plants, severely diseased with *Celery virus 1,* have been studied (11) in the field. They appear badly stunted, leaves are small and distorted but without filiformity, with a grayish dull color making the plants seem starved, blossoms drop, if fruit has set before the plant is infected it becomes malformed, and a mild mottling coupled with a finely ridged moiré pattern occurs on some of the leaves. The disease often starts at the edges of the fields a few days after transplanting, and, once established, usually spreads rapidly.

Under favorable experimental conditions, inoculations on California Wonder peppers, either by aphids or leaf-rubbing methods, often resulted in dark primary lesions that spread downward to the stem and caused systemic symptoms. Primary lesions have been observed within about 4 days after inoculation, and systemic infection resulting in crookneck and vein-clearing symptoms occurred a day or two later.

Cucumber and Summer Squashes: Celery virus 1 attacks cucumber and summer squash plants with about equal severity. When observed in the fields (11), the disease is a vigorous mosaic causing striking stunt and necrosis, and mottling with crumpling of the leaves. The virus usually is found first in plants along the edges of fields, spreading rapidly inwards. Plants may be affected at any time while they are growing, from early seedling stage to when they are mature, bearing fruits ready to harvest. If infection occurs before blossoms are mature, fruits do not set; but when disease occurs a little after this stage, badly stunted, discolored, and slightly malformed, unsalable fruits may be produced.

When cucumber and squash seedlings were inoculated by the leaf-rubbing method, round, sunken, primary lesions were produced on cotyledons, and irregular diffuse primary lesions were produced on leaves in about 3 to 10 days after inoculation. The lesions on Cocozelle squash cotyledons were larger than those on White Spine cucumbers. On both Cocozelle and Golden Summer Crookneck squashes they produced general necrosis of the cotyledons and caused systemic symptoms 2 to 3 days after the lesions were noticed. In cucumbers the reaction was nearly the same, though general

necrosis of cotyledons did not take place until several days had passed. Within 2 weeks after the first leaf mottling occurred, there was little difference in severity of infection in either squashes or cucumbers.

Eggplant and Tomato: The Florida Highbush eggplant was found on a number of occasions infected with the celery virus in the field. The same is true of Globe and Marglobe tomatoes. Diseased plants were slightly stunted, the leaves were mottled in a mild and inconspicuous manner, and, though fruits were somewhat reduced in number and size, they were harvested and the disease caused little important loss in production.

Black Beauty eggplants were inoculated in the greenhouse by the leaf-rubbing method. The first symptoms to appear were vein-clearing, and chlorosis, 10 to 14 days after inoculation. About 6 days later distinct, black, irregularly shaped primary lesions were visible on originally inoculated leaves. Aphid inoculations gave the same results. These experiments were repeated a number of times, and black primary lesions nearly always appeared several days after systemic symptoms were noted on the youngest leaves. No distinct primary lesions were ever observed on Florida Highbush eggplant. On Globe and Marglobe tomatoes, irregular, diffuse, light colored primary lesions occurred occasionally in inoculated leaves, and these symptoms became evident some days after vein-clearing and characteristic mild systemic mottling were established symptoms. Occasional masking of systemic symptoms occurred in eggplant.

Sweet Corn: Corn plants that are conspicuously affected with celery virus infection in the field (9) (11) are stunted, and have leaves that are striped with long but narrow bright yellow bands, running along the veins. The leaves tend to split, may have necrotic streaks, and are of a generally chlorotic appearance. Young seedlings may be killed outright.

Repeated attempts have failed to infect Country Gentleman sweet corn plants by leaf-rubbing methods. Viruliferous aphids, however, have proved a potent means of inoculating seedlings. Primary lesions result from aphid inoculations. It is believed by the writer that his description (9) of these lesions is the first report of such virus-infection phenomena on monocotyledonous hosts. Primary lesions occurred under greenhouse conditions in about 3 days after aphids had fed on the young leaves, and were found with greatest frequency on the first seedling leaf, though they appeared on the second, third, and fourth leaves as well. The start of systemic symptoms consisted in the presence of elliptical spots on the leaves shortly after primary lesions were evident, and a mottling also was often found. These markings gradually changed and coalesced, concentrating the chlorotic effects along veins until within a month's time striping occurred. The stem tissues were affected, the internodes did not lengthen normally, and the plants were severely stunted.

Beet: Garden beets which were naturally diseased with celery virus have not been easy to find in the field. The diseased plants have in some cases a stunted growth, in which the leaves are glazed and held stiffly upright, and a red but mild mottling pattern occurs. At times plants which seemed symptomless but were next to diseased plants were found to contain the virus when their foliage parts were used as inoculum on test plants.

Crosby Egyptian beet plants were inoculated by either leaf-rubbing or aphid methods, and in all cases non-necrotic primary lesions appeared in about 3 days. These lesions were in the form of reddish rings on a green background. Systemic symptoms, which appeared in some cases, developed a number of days after the primary lesions. It was noticeable in the experimental plants that the petioles were brittle in character, and the leaf tissues were in general more thickened and stiff.

Watermelon: The writer has not seen plantings of watermelons growing in regions where he knew the celery virus existed. Kleckley Sweet watermelon plants were grown in the greenhouse, however, and infection by aphids or rubbing methods produced black primary lesions on both cotyledons and young leaves in around 7 days. Symptoms of systemic infection occurred usually a day before primary lesions developed and consisted at first of a light vein-clearing in young leaves. This type of marking faded out, however, the leaves remained small and darker green, mildly but not markedly mottled, and the stems were brownish and woody with short internodes. Plants were considerably stunted and brittle, and one of the striking effects of the disease in the greenhouse was inhibition of flower and tendril formation.

Sweet Potato: The writer has observed sweet potato plants diseased with celery virus in the field in Florida and also has found it (9) in Cuba. Under common cultural practices its presence on sweet potatoes is not especially conspicuous. In the field a mild mottled pattern usually develops, which towards harvest time can hardly be recognized as of virus causation.

Sweet potato plants of the Porto Rico variety were inoculated by aphids and leaf-rubbing methods. The latter technique failed to produce infection, but aphids were successful in transmitting the virus. No primary lesions were produced, but vein clearing appeared in about 7 days after placing aphids on the plants. The vein clearing finally disappeared and the next, younger, leaves to show infection were severely marked with a not very brilliant but distinct mottling characteristic of virus infection on this host. The plants were stunted and produced small roots.

Onion: Onion seedbeds near fields of celery badly diseased with mosaic were examined, and onion seedlings were found which were stunted, and the leaves were generally chlorotic with yellowish markings of rounded and irregular ring shapes. These plants, upon being tested for virus content, proved to be diseased with the celery virus.

Crystal White onion sets and seeds were planted in the greenhouse and the young plants and seedlings used for inoculation experiments. No plants that had been grown from sets were infected, whether inoculated by aphids, needle, hypodermic injections, or the leaf-rubbing method. Upon inoculating very young seedlings, leaf rubbing did not cause infection, but aphid inoculations were successful in causing disease. No primary lesions were observed. The first visible indication of infection appeared as a number of light chlorotic streaks on young leaves. The yellow spots and rings found on older infected plants in the field appeared in diseased plants in the greenhouse. In 6 weeks' time after inoculation, diseased plants had become yellowed, stiff, brittle, and somewhat stunted.

New Zealand Spinach: In several instances celery-virus-diseased New Zealand Spinach plants were found in the field. If diseased weeds had not been adjacent to patches of the vegetable, the New Zealand Spinach plants would not have been believed to be diseased. Symptoms of disease in the field are largely mild mottling, and a slight stunting, and in some cases apparently symptomless plants served as a source of celery virus when juices from them were tested on cucumber cotyledons.

Both leaf-rubbing and aphid inoculations caused inconspicuous, whitish, primary lesions. These were visible at about the same time systemic symptoms appeared. On inoculated plants a mild mottle pattern was produced on the leaves, together with slight stunting, though in many cases no symptoms of any sort occurred.

ORNAMENTAL PLANTS INFECTED BY THE CELERY VIRUS

In selecting the ornamental plants thought necessary to be included in these host-range studies, the first group to be experimented on were those species and varieties found naturally diseased in the Sanford district. The work was then extended to others grown in the region but that apparently remained healthy. A few species commonly grown only in the northern part of the United States also were studied.

In table 2 are listed 23 ornamental host plants that proved susceptible to *Celery virus 1* inoculations. Of these susceptible plants, 10 seemed of particular interest.

Petunia: Rosy Morn petunia plants were found in many gardens, severely affected by the southern celery-mosaic virus. Such plants had mottled leaves, which in a few instances had developed necrotic areas. The stem internodes were much shortened, and under certain conditions distinct necrotic streak symptoms appeared on them. There was often some distortion of the leaf lamina, though no shoestring effects occurred, and in many instances no blossoms developed. In the inoculation experiments, both leaf-rubbing and aphid inoculations caused primary lesions. These

started as small, whitish punctations that enlarged rapidly, becoming slightly yellow, and finally water-soaked and necrotic. Systemic infection symptoms on leaves appeared several days after development of primary lesions, and consisted first of typical vein clearing, and later severe mottling and stunting, which finally ended with necrosis in some cases that extended into the stem tissues. Flowers that showed virus effects were of particular interest. In some cases they were only partially developed being unable to open up completely. Other plants bore flowers that opened normally but were mottled with streaks and concentric irregular rings.

Periwinkle: Symptoms of celery-virus attack on periwinkle plants in the field were frequently observed. Periwinkle, grown as an annual in the North, is treated as more or less perennial in Florida and often manages to exist for years with fairly severe virus symptoms on its leaves. These symptoms in the field are largely confined to marked mottling, and slight stunt-

TABLE 2.—*Results of studies on the ornamental plant hosts that proved susceptible to Celery virus 1 (Compare also with Table 5 for species names, number of plants used, and recovery of virus)*

No.[a]	Ornamental Plant	Inoculation methods	Symptoms[b]	Occurrence in field
89	African Marigold	Rubbing	.....S–D–M	+
57	Belladonna	"	.....M	
51	California Bluebell	"	.....M–N	
50	Chinese Forget-me-not	"	LO–M–D–S	
14	Easter Lily	Aphid[c]	LN–M–S–Y	+
88	French Marigold	Rubbing	.....S–D–M	+
90	Floras Paintbrush	Aphid, rubbing	LO–M	+
33	Geranium	Aphid[c]	.....M–S	+
28	German Catchfly	Aphid, rubbing	.....M–S–D	
49	Gilia	Rubbing	.....S–M	
15	Golden Lily	Aphid[c]	.....M–N–S	
27	Iceplant	Rubbing	LN–M–S–D	
29	Larkspur	"	LN–Y–S–M	+
44	Madagascar Periwinkle	Aphid, rubbing	LO–M–S–D	+
46	Morning Glory	Aphid	.....M–S	+
34	Nasturtium	Rubbing	LD–O	
74	Petunia	Aphid, rubbing	LN–S–M–N–D	+
52	Phacelia	Rubbing	.....S–N–M	
48	Phlox	" [d]	LC–O	
75	Snapdragon	Aphid, rubbing	LW–Y–S–M	+
76	Sweet Scabiosa	Rubbing	.....M	
12	Wandering Jew	Aphid[c]	LO–M–S	+
87	Zinnia	Rubbing	LO–S–M–D–Y	+

[a] These numbers refer to host species identically numbered in Table 5.

[b] L refers to primary lesions: C-chlorophyll retention on yellowed leaves, D-diffuse, N-necrotic, O-none developed, W-whitish, ... uncertain of production. Other single letters refer to systemic symptoms: D-distortion, M-mottling, *M-masking*, N-necrosis, O-no symptoms and no virus recovered, S-stunting, Y-yellowing.

[c] Rubbing methods of inoculation did not produce infection.

[d] Aphid inoculations did not produce infection.

ing. Aphid and leaf-rubbing inoculations were made on plants grown under experimental conditions, infection occurred but no primary lesions were observed. The first systemic symptom was a peculiar streaked mottling on the leaves, which later increased in severity. Disease resulted in downward curvature of the leaves and shortened internodes; in some cases no flowers were produced. Where flowers did develop they were small, though not noticeably malformed.

Larkspur: Annual larkspur plants, infected in the field with the celery virus, were markedly stunted and chlorotic and did not produce flowers. Both juice and aphid inoculations proved successful in producing the disease experimentally. Diseased plants were much flattened in growth and had a rosette appearance; leaflets chlorotic, curled down, and in a few cases mottled with light green.

Zinnia: On zinnias in the field the celery virus disease causes severe stunting and mottling. Experimental inoculations did not produce primary lesions, though severe systemic mottling, distortion, chlorosis, and stunting occurred. The colors of diseased zinnia flowers are abnormal with tan and dirty grey markings on the distorted, irregular, and stiff petals. The flower stalk is shortened and the numbers of flowers produced much reduced.

Easter Lily: Both the Easter lily and the Golden lily were found to be susceptible to aphid inoculation with the celery virus. Diseased Easter lily plants were found in abundance in fields, and in all cases the relationship of infected plants and diseased wild hosts was distinctly observed. The Easter lily was found to be affected by at least one other virus disease in Florida, but this trouble differed in symptoms, did not spread rapidly, and was observed on young stock as soon as it was above ground. The celery-virus disease apparently did not occur in the bulbs, but appeared only after aphids had fed on the plants in the field. Celery-virus diseased Easter lily plants are stunted, with leaves flattened out and grey, often with small necrotic spots on them. Flower development is sometimes inhibited. When flowers unfold, they may be small and greenish in color but do not split or develop malformations.

Wandering Jew: Plants of the common purple wandering jew were observed naturally infected with the celery virus in 2 gardens. The diseased plants were not easily discovered but were somewhat stunted with slight twisting of leaves, and a light colored mottling interrupting the broad purple stripes on their under surfaces. Healthy plants were inoculated in the greenhouse and the use of viruliferous aphids was the only successful method of infecting the plants. No primary lesions were produced, and the typical systemic symptoms seen on diseased plants growing in outside gardens resulted.

Snapdragon: Snapdragon plants affected with celery virus were found occurring naturally in the field. They appeared somewhat chlorotic, stunted, and mildly mottled. Inoculation of plants in the greenhouse by rubbing leaves with viruliferous juices produced whitish primary lesions. Aphid inoculations seemed to cause no primary lesions but resulted in systemic infection.

Iceplant: Infection of iceplants was obtained through leaf-rubbing methods. In these plants the first symptom consisted in the manifestation of grey primary lesions, which rapidly became diffuse and were somewhat necrotic. The thick, fleshy leaves of this plant were inoculated on their ventral surfaces. The necrotic appearance of primary lesions did not extend to the dorsal side of the leaf. Systemic-mottling symptoms, which developed on other leaves, were noted on both sides of leaves systemically infected. At times some of these leaves were considerably distorted; under other conditions they were simply smaller than normal.

Phlox: Phlox was studied in the field for natural infection, but nothing of the sort was observed, even in beds surrounded with infected weed hosts. Seedlings grown in the greenhouse were inoculated with aphids but the trials failed, while leaf-rubbing methods produced a few scattered primary lesions. These lesions were neither large nor necrotic. They were first whitish in appearance, but later recovered their greenness, retaining their chlorophyll when the rest of the leaf yellowed and dropped.

Floras Paintbrush: The juice from a few wild plants of Floras paintbrush was shown to contain *Celery virus 1* when inoculated into test hosts. This inoculation was repeated a number of times with consistent results. Such plants were perhaps at first very slightly stunted, though they grew and flowered normally later on. When inoculation studies were performed in the greenhouse, the juice from some inoculated plants still contained the virus 3 weeks after leaf-rubbing or aphid infections, and none of the untouched plants had infectious juices. Taken by themselves, the inoculated plants appeared symptomless from the very first, and grew, flowered, and fruited in a seemingly perfectly normal manner. This was a species that, under the conditions of the experiments, was judged by the writer to be a good example of a masked carrier.

WEED HOSTS OF THE CELERY VIRUS

In the Sanford region it has been of considerable importance to know what wild plants growing around cultivated areas are capable of acting as hosts of the celery virus, since one of the methods of control of this virosis of celery (7) has been the removal of these weed hosts from around celery fields. Although one weed, the wild wandering jew, *Commelina nudiflora*, has been considered the principal reservoir-host of the southern celery

mosaic, it has become increasingly evident that other weeds are also of great significance in the spread of the virus to other crops. In table 3 are found the results of studies of weed hosts of *Celery virus 1.*

TABLE 3.—*Results of studies on weed hosts of the southern celery-mosaic virus (Compare also with Table 5 for species names, number of plants used, and recovery of virus)*

No.[a]	Weed host	Inoculation methods	Symptoms[b]	Occurrence in field
45	Bindweed	Aphid	.....M–S	+
32	Crane's-bill	" [c]	.....M–D–S	+
10	Creeping Day-flower	" [c]	LO–M	+
20	Lamb's Quarters	Rubbing[d]	LW–O	
53	Nightshade	" [d]	LW–O	
61	*Physalis angulata*	Aphid, rubbing	LD–M–Y–N–S	+
62	*Physalis lagascae*	Aphid	.....M–S–N	+
63	*Physalis sp.*	Aphid	LN–M–N	+
24	Pokeberry (Common)	Aphid, rubbing	LW–O	
25	Pokeberry (Southern)	" "	LW–M–S	+
86	Ragweed	" "	.....M–S–D–N	+
82	West Indian Gherkin	"	.....S–M–D	+
11	Wild Wandering Jew	" [e]	LO–M–Y	+

[a] These numbers refer to host species identically numbered in table 5.

[b] L refers to primary lesions: D-diffuse, N-necrotic, O-none developed, W-whitish, ...-uncertain of production. Other single letters refer to systemic symptoms: D-distortion, M-mottling, N-necrosis, O-no symptoms and no virus recovered, S-stunting, Y-yellowing.

[c] Leaf-rubbing methods failed to produce infection.

[d] Aphid inoculation methods failed to produce infection.

[e] Leaf-rubbing methods failed to produce infection but occasional infection was secured by hypodermic needle injection, stem and leaf mutilation methods with needle, and grafting methods.

It should be noted that the writer has studied, with some possible exceptions, the most common weeds that might obviously be hosts of the southern celery-mosaic virus occurring in the vegetable growing district around Sanford, Florida. There are undoubtedly many more susceptible wild hosts than those in table 3. Hosts that were tested, but gave negative results, are in the list that occurs on page 399, at the close of the discussion of experimental results. It is believed that 5 of the susceptible hosts are of sufficient interest to require individual description.

Wild Wandering Jew: Plants of the wild wandering jew, diseased with a virus, have been found widely distributed in nature (7) (8) (9) (11). They occur with great frequency in the weed patches along the edges of cultivated fields in the Sanford region and many other parts of Florida.

The spread of the celery virosis has been studied (11) in fields of this weed. The most important symptom is a mottling, which varies under some conditions from light green watered effects and mild mottling to irregular elliptical rings of bright yellow on the leaves. The chlorosis in some cases is so severe that it may involve a large proportion of the leaf. There is practically no distortion or stunting; generally the plant lives, flowers, and sets seed about as successfully when diseased as when free from the virus. Wild wandering jew was easily inoculated by aphids, but leaf-rubbing methods were uniformly unsuccessful.[2] No primary lesions developed, and the first symptom of infection was a light slightly water-soaked stripe that appeared in 10–18 days after inoculation. This striping became a vein-clearing pattern that, within a few days, changed into the mottling described.

Ragweed: Plants of ragweed with severe systemic mottling are usually easily found in the field (11). Such plants are somewhat stunted, the degree depending upon their ages when infected. The leaves tend to be small and marked with small yellow irregular spots. In some cases there is leaf distortion, and at times necrosis occurs. Under greenhouse conditions, ragweed seedlings have been infected by both aphid and leaf-rubbing methods of inoculation. No primary lesions have been observed, the first symptom being vein-clearing, which changed to yellow mottling. If plants are inoculated when growing under either unfavorably cool or dry conditions, or when in infertile soil, the bright mottled symptoms described are reduced to faint markings that verge on assuming a masked character. Diseased plants apparently were not much inhibited in flower and seed production.

Crane's-bill: Symptoms of virus infection in crane's-bill consist largely of stunting, mottling, and some distortion of the leaves. Inoculation with aphids resulted in producing disease, while leaf-rubbing methods gave negative results. No primary lesions were noted. Systemic symptoms were quite severe but did not inhibit seed production.

Physalis angulata: A wild Physalis (*P. angulata*) was frequently found in the field with a virus-diseased appearance. Seedlings were grown in the greenhouse and both aphid and leaf-rubbing methods of inoculation produced infection. Leaf rubbing resulted in the development of rounded yellowish primary lesions. In a few cases these affected leaves were dropped and the plant that bore them escaped infection. When aphids were used for inoculation, primary lesions and leaf drop affected the older leaves; but when the insects fed on the very young leaves as well, systemic

[2] While leaf-rubbing methods of inoculation have been unsuccessful in infecting *Commelina nudiflora*, it should be noted that needle inoculation in tips of stems, hypodermic injection methods, inarch or approach grafting methods, and tying of tips of bruised, healthy, and diseased tips together, have all been successfully used as means of obtaining virus transmission.

infection always occurred. The leaves of systemically infected plants were mottled, the plants were stunted, flowering and fruiting was reduced, and in some cases a dark streak type of necrosis occurred on the stems that resulted in dropping of leaves.

Southern Pokeberry: Pokeberry plants with brilliant systemic mottling of leaves were found in many different fields. All seedlings of this weed, grown in the greenhouse, were readily susceptible to primary infection with *Celery virus 1*, either through the use of aphids or leaf rubbing. In all cases primary lesions developed. These were midsize, round, whitish spots on inoculated leaves. Sometimes primary infected leaves were dropped and the virus did not become systemic. The remaining leaves of such individuals were, however, susceptible to infection, which apparently remained localized in the affected leaves. In a small number of cases systemic infection occurred, producing brilliantly mottled leaves but no severe reduction in growth of the plant, flower, or fruit production.

MISCELLANEOUS PLANTS SUSCEPTIBLE TO CELERY VIRUS

Certain plants that did not fall under the arbitrary classifications of vegetable crops, weeds, or ornamentals, were used in the study of the southern celery mosaic. Some of these hosts were convenient for use as material in the virus property studies (8), others were related to hosts already known to be susceptible, and symptoms on others, *e.g.*, banana varieties (10) and field corn, were studied as possible clues to relationships of viroses described by other workers on these hosts. Some of the results of these studies are reported in table 4, the rest of the data being in table 5.

The susceptibility of certain of the miscellaneous hosts was, it is believed, of special interest. Some have been, therefore, selected for short detailed descriptions.

Banana: Banana plants were inoculated by both aphid and leaf-rubbing methods. Infection was successful only when aphids were used to transmit the virus (10). No primary lesions were developed. The first symptoms of systemic infection occurred, after about a month's incubation period, on a leaf that was not visible at the time aphids were put on the plant to be inoculated. The first leaf to show symptoms was mottled along the veins. Later leaves were stunted, somewhat chlorotic, distorted, and marked with occasional black necrotic streaks. The leaf sheaths were arrested in their development, which caused a rosette of leaves and occasionally splitting of the pseudostem. Formation of the fruiting bud was inhibited in plants diseased at an early age.

Tobacco: A few seedlings of a broad-leaf type of tobacco affected with the celery virosis were found in a seedbed in the Sanford region. These plants were severely stunted and mottled and there was considerable leaf

TABLE 4.—*Results of studies on certain miscellaneous plants found susceptible to Celery virus 1 (compare also with Table 5 for species names, number of plants used, and recovery of virus)*

No.[a]	Miscellaneous plant	Inoculation method	Symptoms[b]	Occurrence in field
31	Broadbean	Rubbing	LP–O	
19	Buckwheat	"	.....M–S–D	
17	Cavendish Banana	Aphid	.....M–S–N–Y	
85	Chayote	Rubbing	LB–O	
4	Corn (U. S. D. A. strains)	Aphid[c]	LN–M–S–N–*S*	
72	*Datura meteloides*	Rubbing	LD–O	
3	Field Corn	Aphid[c]	LN–M–S–N–*S*	+
73	Jimson Weed	Rubbing	LD–O	
7	Kafir Corn	Aphid	.....M–*M*	
18	Lady Finger Banana	" [c]	LO–M–N–D–S–Y	+
6	Milo Maize	"	.....M–*M*	
64	Nicandra (Apple-of-Peru)	Rubbing	.....M	
68	*Nicotiana glutinosa*	Aphid, rubbing	LW–N–Y–M–S	
67	*Nicotiana sanderae*	Rubbing	.....M	
71	*Nicotiana sylvestris*	"	.....M	
60	*Physalis peruviana*	"	.....M	
9	Rye	Aphid[c]	.....M–Y	+
13	Spiderwort	"	.....Y–S–D–M	
5	Sweet Sorghum	"	.....M–S	+
65	Tabasco Pepper	Aphid, rubbing	LN–S–M–N	
1	Teosinté	Aphid[c]	.....M–Y–S	
69	Tobacco, Broadleaf	Aphid, rubbing	LN–M–D–N–S	+
70	Tobacco, Turkish	" "	LN–M–D–N–S	
8	Wheat	Aphid[c]	.....M–Y	
54	*Solanum aviculare*	Rubbing	LN	

[a] These numbers refer to host species identically numbered in table 5.

[b] L refers to primary lesions: P-purplish and small, B-black, D-diffuse, N-necrotic, O-none produced, W-whitish, ...-uncertain of production. Other single letters refer to systemic symptoms: D-distortion, M-mottling, *M-masking*, N-necrosis, O-no symptoms and no virus recovered, *S-striping*, S-stunting, Y-yellowing.

[c] Leaf-rubbing methods tried but failed to produce infection.

crumpling. Under greenhouse conditions, inoculations of plants of Broadleaf tobacco, Turkish tobacco, and *Nicotiana glutinosa* (*cf.* (8)) gave practically identical results. Infections were easily secured, whether by the use of either aphid or leaf-rubbing methods. Primary lesions occurred on plants infected by either method. They were not always visible, however, because of certain growing conditions during the incubation period. When primary lesions did develop they were whitish spots that became whiter for several days. In many cases some necrosis and collapse of tissues occurred as these symptoms advanced. In older leaves the non-necrotic whitish primary lesions started recovering and retaining their chlorophyll at about the time inoculated leaves began turning yellow from age. Symptoms of the first systemic infection usually were indicated by a brilliant vein clearing and crumpling of the young affected leaves. These symptoms changed

to a yellow and green mottling, and occasionally systemic necrosis developed. No diseased tobacco or *Nicotiana glutinosa* plants that were kept long enough, failed to bear seed capsules, although the fruits were fewer in numbers than from virus-free individuals.

Buckwheat: Plants of buckwheat were inoculated by the leaf-rubbing method and infected by the celery virus. The systemic mottling that developed on the leaves was very severe, accompanied by their malformation and a general stunting of the plants.

Wheat: Several varieties of wheat were grown and inoculated with aphid and leaf-rubbing methods. Aphid inoculations were alone successful in producing infection. No primary lesions were observed, and systemic symptoms of infection consisted of light and dark green mottling of leaves. No stunting was detected, nor were rosette types of symptoms noted.

Rye: Inoculation of rye seedlings with viruliferous aphids produced successful infection with the celery virus. Systemic symptoms were very similar to those noted on Commelina. Plants were not stunted and markings consisted largely at first of fine indistinct yellowish stripes of vein-clearing type, which soon turned to irregularly rounded and elliptical rings and spots.

Teosinté: Plants of teosinté were successfully infected with the celery virus by using aphids. No primary lesions were observed. When the virus had become systemic, the leaves had a generally yellowish cast due to a large number of small yellow spots. Diseased plants were small but not severely stunted, the leaves were chlorotic but not seriously yellowed, and the plants appeared to blossom at the same time as healthy individuals. Infected plants produced about as many seeds as did virus-free individuals.

Chayote: Leaves on several chayote vines were inoculated with celery virus by the leaf-rubbing method. Infection was nonsystemic and occurred as a few black, irregular, primary lesions.

Broadbean: Leaves on plants of broadbean produced small, dark, purplish primary lesions when inoculated with celery virus by the leaf-rubbing method. The lesions occurred on all plants tested, but apparently did not spread to produce systemic infection. The virus was not recovered from noninoculated leaves of the host.

COMPLETE EXPERIMENTAL HOST RANGE OF CELERY VIRUS 1

Table 5 presents in condensed form data from host-range studies that gave positive results. The susceptible hosts are arranged according to families. The numbers of plants inoculated and those infected are noted. Results of attempts at recovery of virus from leaves affected in different ways on the infected plants are also indicated. For complete data on symptoms produced by infection, for inoculation methods employed to pro-

TABLE 5.—*The complete experimental host range of Celery virus 1. These data are supplemented by other results, methods of inoculation, symptoms, and field occurrence, in the previous tables 1, 2, 3, and 4*

Family	Host names and number	Number of plants: Inoculated / Infected	Recovery of virus: Leaves tested	Recovery of virus: Result	Compare table
Gramineae	*Euchlaena mexicana* Schrad.	18	Inoculated	+	4
	(1—Teosinté)	16	Mottled	+	
	Zea mays L.	210	Inoculated	+	1
	(2—Maize, Sweet corn)[a]	120	Striped	+	
	Z. mays	27	Inoculated	+	4
	(3—Maize, Field corn)[a]	16	Striped	+	
	Z. mays	149	Inoculated	+	4
	(4—Corn, strains from U.S.D.A.)[a]	141	Striped	+	
	Holcus sorghum L.	29	Inoculated	....	4
	(5—Sweet sorghum)	13	Mottled	+	
	H. sorghum	33	Inoculated	....	4
	(6—Milo)	18	Mottled	+	
	H. sorghum	15	Inoculated	....	4
	(7—Kafir corn)	5	Mottled	+	
	Triticum aestivum L.	70	Inoculated	+	4
	(8—Wheat)[a]	42	Mottled	+	
	Secale cereale L.	20	Inoculated	....	4
	(9—Rye)	19	Mottled	+	
Commelinaceae[b]	*Commelina communis* L.	20	Inoculated	+	3
	(10—Creeping Day-flower)	20	Mottled	+	
	C. nudiflora L.	118	Inoculated	+	3
	(11—Wild Wandering Jew)	98	Mottled	+	
	Zebrina pendula Schnizl.	16	Inoculated	0	2
	(12—Wandering Jew)	16	Mottled	+	
	Tradescantia sp.	9	Inoculated	+	4
	(13—Spiderwort)	4	Mottled	+	
Liliaceae	*Lilium longiflorum* Thunb.	10	Inoculated	....	2
	(14—Easter Lily)	7	Mild mottled	+	
	Lilium auratum Lindl.	15	Inoculated	+	2
	(15—Golden Lily)	2	Mottled	+	
	Allium cepa L.	60	Inoculated	....	2
	(16—Onion)	15	Yellowed	+	
Musaceae	*Musa cavendishii* Lamb.	2	Inoculated	0	4
	(17—Cavendish banana)	2	Mottled	0	
	M. sapientum L.	15	Inoculated	0	4
	(18—Lady Finger banana)	13	Mottled	0	

TABLE 5.—(*Continued*)

Family	Host names and number	Number of plants: Inoculated / Infected	Recovery of virus: Leaves tested	Recovery of virus: Result	Compare table
Polygonaceae	*Fagopyrum esculentum* Gaertn.	10	Inoculated	.....	4
	(19—Buckwheat)	10	Mottled	+	
Chenopodiaceae	*Chenopodium murale* L.	16	Inoculated	+	3
	(20—Lamb's Quarters)	3	Symptomless	0	
	Beta vulgaris L.	25	Inoculated	+	1
	(21—Red Garden beet)	25	Mild mottled	+	
	B. vulgaris cicla	9	Inoculated	+	1
	(22—Swiss Chard)	2	Symptomless	0	
	Spinacia oleracea L.	43	Inoculated	+	1
	(23—Spinach)	38	Yellowed	+	
Phytolaccaceae	*Phytolacca americana (decandra)* L.	25	Inoculated	+	3
	(24—Pokeberry, common)	15	Symptomless	0	
	P. rigida Small	67	Inoculated	+	3
	(25—Pokeberry, southern)	65	Symptomless	0	
Aizoaceae	*Tetragonia expansa* L.	14	Inoculated	+	1
	(26—New Zealand Spinach)	4	Symptomless	+	
	Mesembryanthemum crystallinum L.	10	Inoculated	+	2
	(27—Iceplant)	10	Malformed	+	
Caryophyllaceae	*Lychnis viscaria* L.	5	.....	.....	2
	(28—German Catchfly)	5			
Ranunculaceae	*Delphinium consolida* L.	23	Inoculated	+	2
	(29—Larkspur)	23	Stunted	+	
Cruciferae	*Brassica rapa* L.	15	Inoculated	+	1
	(30—Turnip, Purple Top White Globe)[c]	3	Symptomless	0	
Leguminosae	*Vicia faba* L.	10	Inoculated	+	4
	(31—Broadbean)	10	Symptomless	0	
Geraniaceae	*Geranium carolinianum* L.	25	Inoculated	+	3
	(32—Crane's-bill)	20	Mottled	+	
	Pelargonium hortorum Bailey	5	Inoculated	+	2
	(33—Common Bedding Geranium)	5	Mottled	+	
Tropaeolaceae	*Tropaeolum majus* L.	5	Inoculated	+	2
	(34—Nasturtium)	5	Symptomless	0	
Umbelliferae	*Daucus carota* L.	40	Inoculated	0	1
	(35—Carrot)	31	Mottled	+	
	Anethum graveolens L.	5	Inoculated	...	1
	(36—Dill)	5	Yellowed	+	

TABLE 5.—(*Continued*)

Family	Host names and number	Number of plants	Recovery of virus		Compare table
		Inoculated / Infected	Leaves tested	Result	
Umbelliferae	*Foeniculum vulgare* Hill	17	Inoculated	—	1
	(37—Fennel)	4	Stunted	+	
	Petroselinum hortense Hoffm.	65	Inoculated	+	1
	(38—Parsley)[a]	59	Mottled	+	
	Apium graveolens L.	150	Inoculated	+	1
	(39—Celery, Golden types)[a]	140	Mottled	+	
	A. graveolens L.	10	Inoculated	—	1
	(40—Celery, flavoring)	10	Mottled	+	
	A. graveolens L.	25	Inoculated	+	1
	(41—Celery, Green Pascal)	15	Mottled	+	
	A. graveolens rapaceum	15	Inoculated	0	1
	(42—Celeriac)	9	Mottled	+	
	Pastinaca sativa L.	15	Inoculated	—	1
	(43—Parsnip)	9	Mottled	+	
Apocynaceae	*Vinca rosea* L.	35	Inoculated	+	2
	(44—Madagascar Periwinkle)	35	Mottled	+	
Convolvulaceae	*Convolvulus sp.*	15	.....	—	3
	(45—Bindweed)	12			
	Ipomoea purpurea Lam.	6	Inoculated	+	2
	(46—Morning glory)	3	Mottled	+	
	I. batatas Lam.	33	Inoculated	+	1
	(47—Sweet Potato)[a]	25	Mottled	+	
Polemoniaceae	*Phlox drummondii* Hook	20	Inoculated	+	2
	(48—Phlox)	20	Symptomless	0	
	Gilia capitata Dougl.	12	Inoculated	0	2
	(49—Gilia)	6	Mottled	+	
Boraginaceae	*Cynoglossum amabile* Stapf & Drum.	5	.....	—	2
	(50—Chinese Forget-me-not)	5			
Hydrophyllaceae	*Phacelia whitlavia* Gray	15	Inoculated	0	2
	(51—California Bluebell)	12	Mottled	+	
	P. tanacetifolia Benth.	13	Inoculated	+	2
	(52—Phacelia)	13	Necrotic	+	
Solanaceae	*Solanum nigrum* L.	42	Inoculated	+	3
	(53—Nightshade)	40	Symptomless	0	
	S. aviculare Forst.	12	.....	—	4
	(54—*Solanum aviculare*)	6			

TABLE 5.—(*Continued*)

Family	Host names and number	Number of plants: Inoculated / Infected	Recovery of virus: Leaves tested	Recovery of virus: Result	Compare table
Solanaceae	*S. melongena* L. (55—Eggplant)	41 / 17	Inoculated Mottled	+ +	1
	Lycopersicon esculentum Mill. (56—Tomato)	45 / 10	Inoculated Mottled	0 +	1
	Atropa belladonna L. (57—Belladonna)	5 / 5	.....	.....	2
	Physalis alkekengi L. (58—Strawberry groundcherry)	5 / 5	Inoculated Mottled	+ +	1
	P. pubescens L. (59—Common groundcherry)	12 / 12	Inoculated Mottled	+ +	1
	P. peruviana L. (60—*Physalis peruviana*)	9 / 9	Inoculated Mottled	..... +	4
	P. angulata L. (61—*Physalis angulata*)	29 / 19	Inoculated Mottled	+ +	3
	P. lagascae R. & S. (62—*Physalis lagascae*)	14 / 12	Inoculated Mottled	+ +	3
	P. sp. (63—*Physalis sp.*)	6 / 6	Inoculated Mottled	+ +	3
	Nicandra physalodes Pers. (64—Nicandra, Apple-of-Peru)	5 / 5	.....	.....	4
	Capsicum annuum L. (65—Tabasco Pepper)	31 / 31	Inoculated Mottled	+ +	4
	C. frutescens L. (66—Sweet Pepper)[a]	32 / 28	Inoculated Mottled	+ +	1
	Nicotiana sanderae Sander. (67—Nicotiana)	14 / 7	.....	.....	4
	N. glutinosa L. (68—*Nicotiana glutinosa*)	24 / 24	Inoculated Mottled	+ +	4
	N. tabacum L. (69—Broadleaf tobacco)	57 / 57	Inoculated Mottled	+ +	4
	N. tabacum L. (70—Turkish tobacco)	25 / 25	Inoculated Mottled	+ +	4
	N. sylvestris Spegaz. & Comes. (71—*Nicotiana sylvestris*)	5 / 5	Inoculated Mottled	..... +	4
	Datura meteloides DC. (72—*Datura meteloides*)	4 / 4	Inoculated Symptomless	+ 0	4

TABLE 5.—(*Continued*)

Family	Host names and number	Number of plants	Recovery of virus		Compare table
		Inoculated / Infected	Leaves tested	Result	
Solanaceae	*D. stramonium* L.	9	Inoculated	+	4
	(73—Jimson weed)	9	Symptomless	0	
	Petunia hybrida Vilm.	30	Inoculated	+	2
	(74—Petunia)[a]	30	Mottled	+	
Scrophulariaceae	*Antirrhinum majus* L.	16	Inoculated	+	2
	(75—Snapdragon)	16	Chlorotic	+	
Dipsaceae	*Scabiosa atropurpurea* L.	5	Inoculated	+	2
	(76—Sweet Scabiosa)	5	Mottled	+	
Cucurbitaceae	*Cucurbita pepo* L.	12	Inoculated	.....	1
	(77—Pumpkin)	5	Mottled	+	
	C. pepo condensa	40	Inoculated	+	1
	(78—Golden Summer Crookneck squash)	39	Mottled	+	
	C. pepo condensa	40	Inoculated	+	1
	(79—Cocozelle squash)	39	Mottled	+	
	C. maxima Duchesne	5	Inoculated	+	1
	(80—Hubbard squash)	5	Mottled	0	
	Citrullus vulgaris Schrad.	37	Inoculated	+	1
	(81—Watermelon)[a]	31	Mottled	+	
	Cucumis anguria L.	5	Inoculated	.....	3
	(82—West Indian Gherkin)	5	Mottled	+	
	C. sativus L.	100	Inoculated	+	1
	(83—Cucumber)[a]	100	Mottled	+	
	C. melo L.	20	Inoculated	+	1
	(84—Muskmelon)[a]	17	Mottled	+	
	Chayota edulis Jacq.	7	Inoculated	+	4
	(85—Chayote)	3	Symptomless	0	
Compositae	*Ambrosia elatior* (*artemisiifolia*) L.	75	Inoculated	.....	3
	(86—Ragweed)	62	Mottled	+	
	Zinnia elegans Jacq.	10	Inoculated	.....	2
	(87—Zinnia)	10	Mottled	+	
	Tagetes patula L.	5	Inoculated	.....	2
	(88—French Marigold)	5	Mottled	+	
	T. erecta L.	5	Inoculated	.....	2
	(89—Aztec Marigold)	5	Mottled	+	
	Emilia sagittata (Vahl.) DC.	20	Inoculated	+	2
	(90—Floras Paintbrush)	20	Symptomless	+	

[a] Several varieties used.

[b] Since completing these trials further study was made on *Commelina erecta* L., which up until preparation of this manuscript appeared to be immune to celery virus infection. Of 47 plants 2 were diseased when inoculated by aphids, virus was recovered; no infected plants have ever been seen in the field.

[c] The author secured these data from one trial on turnips in Florida. Numerous other attempts on the same variety and several others failed to secure infection. These latter trials extended for over 2 years (see Table 1, footnote d, and the list of negatively reacting hosts on page 399).

duce infection, and for occurrence of the disease in the field, see tables 1, 2, 3, and 4, as indicated in the accompanying table.

In many cases many more plants than are listed in table 5 were used in inoculation studies. The preliminary trials, and other unsuccessful attempts performed to ascertain the best methods and ages of plants to be inoculated are not included in the table. Examples of certain of these numbers of plants not included in the table may be cited: over 200 corn seedlings used in studying possible effects of leaf-rubbing methods; about 150 tomato plants inoculated at different times on cotyledons; 112 plants of *Commelina nudiflora* inoculated with hypodermic needle, leaf-rubbing and mutilation methods; 36 onion plants grown from sets inoculated in every conceivable manner; many annual ornamentals inoculated at a very young stage; nearly 1000 plants of numerous species that were growing poorly and were inoculated during cold cloudy spells; and several series of plants of various species, discarded because accidental infection occurred in untouched as well as inoculated individuals.

HOSTS THAT GAVE NEGATIVE REACTION TO CELERY-VIRUS INOCULATIONS[3]

Polypodium vulgare L. (Polypody fern), *Adiantum capillus-veneris* L. (Southern maidenhair fern), *Typha angustifolia* L. (Cat-tail), *Saccharum officinarum* L. (Sugar cane), *Stenotaphrum secundatum* Kuntze (St. Augustine grass), *Panicum barbinode* Trin. (Para grass), *Tricholaena rosea* Nees (Natal grass), *Oryza sativa* L. (Rice), *Avena sativa* L. (Oat)[a], *Cynodon dactylon* Pers. (Bermuda grass), *Hordeum vulgare* L. (Barley)[a], *Poa pratensis* L. (Kentucky Blue grass), *Cyperus compressus* L., *Cyperus esculentus* L. (Chufa), *Xanthosoma sp.* (Elephant's-ear), *Pontederia cordata* L. (Pickerelweed), *Piaropus crassipes* (Mart.) Britton (Common Water hyacinth), *Dendropogon usneoides* (L.) Raf. (Spanish moss), *Ananas sativas* Schult. (Pineapple), *Tillandsia fasciculata* Sw. (Air plant), *Commelina erecta* L.[b], *Tulipa gesneriana* L. (Tulip), *Asparagus officinalis* L. (Asparagus), *A. plumosus* Baker (Asparagus fern), *Sansevieria thrysiflora* Thunb. (Bowstring hemp), *Hemerocallis flava* L. (Yellow day lily), *Yucca gloriosa* L. (Spanish dagger), *Hippeastrum vittatum* Herb. (Amaryllis), *Hymenocallis* sp. (Spider lily), *Narcissus tazetta* L. (Narcissus), *Dioscorea bulbifera* L. (Air potato), *Gladiolus lemoinei* Hort. (Gladiolus), *Canna glauca* L. (Canna), *Chenopodium botrys* L. (Jerusalem oak), *Kochia scoparia* Schrad. (Summer cypress), *Amaranthus spinosus* L. (Spiny pig-

[3] Throughout this section the lower-case superior letters after the names of plants can be interpreted as follows:

[a] A number of different named varieties tested.

[b] See footnote b in table 5.

[c] See footnote d in table 1, and footnote c in table 5.

[d] Tender seedlings tested while succulent.

weed), *A. hybridus* L. (Princes feather), *Celosia argentia* L. (Cockscomb), *Gomphrena globosa* L. (Globe amaranth), *Mirabilis jalapa* L. (Four o'clock), *Portulaca grandiflora* Hook (Rose moss), *Alsine media* L. (Chickweed), *Dianthus plumarius* L. (Grass pink), *D. caryophyllus* L. (Carnation), *Gypsophila paniculata* L. (Babies'-breath), *Nigella damascena* L. (Love-in-a-mist), *Papaver somniferum* L. (Opium poppy), *P. orientale* L. (Oriental poppy), *P. rhoeas* L. (Shirley poppy), *Brassica oleracea* L. *acephala* (Kale), *B. oleracea gemmifera* (Brussels sprouts), *B. oleracea capitata* (Red cabbage),[a] *B. oleracea capitata* (Green cabbage),[a] *B. oleracea capitata* (Savoy cabbage), *B. olercea botrytis* (Cauliflower),[a] *B. oleracea botrytis* (Broccoli),[a] *B. caulorapa* Pasq. (Kohlrabi), *B. napus* L. (Rape), *B. napobrassicae* Mill. (Rutabaga), *B. rapa* L. (Turnip),[a, c] *B. pekinensis* Rupr. (Chinese cabbage, Petsai), *B. nigra* Koch (Black mustard), *B. alba* Rabenh. (White mustard), *Lepidium virginicum* L. (Peppergrass), *Mathiola incana* R. Br. (Stock), *Lobularia maritima* Desv. (Sweet alyssum), *Iberis umbellata* L. (Candytuft), *Raphanus sativus* L. (Radish),[a] *Reseda odorata* L. (Mignonette), *Rosa dilecta* Rehd. (Radiance rose), *R. laevigata* Michx. (Cherokee rose), *Pisum sativum* L. (Garden pea),[a] *Lathyrus odoratus* L. (Sweet pea),[a] *Cicer arietinum* L. (Chickpea, Garbanzo), *Arachis hypogaea* L. (Peanut), *Phaseolus vulgaris* L. (Garden bean),[a] *P. limensis* Macf. (Lima bean), *Chapmania floridana* T. & G. (Bush clover), *Vigna sinensis* Endl. (Cowpea),[a] *Dolichos lablab* L. (Hyacinth bean), *Clitoria ternatea* L. (Butterfly pea), *Crotalaria spectabilis* Roth. (Rattlebox), *Crotalaria sp.*, *Glycine max* Merr. (Soybean),[a] *Trifolium repens* L. (White clover), *Lupinus hirsutus* L. (European blue lupine), *Ionoxalis violacea* (L.) Small (Violet wood-sorrel), *Xanthoxalis corniculata* (L.) Small (Yellow Wood-sorrel), *Citrus grandis* Osbeck (Grapefruit),[d] *C. aurantium* L. (Sour orange),[d] *C. sinensis* Osbeck (Orange),[d] *C. nobilis* Lour. (Tangerine),[d] *Euphorbia pulcherrima* Willd. (Poinsettia), *E. marginata* Pursh. (Snow-on-the-mountain), *Codiaeum variegatum* Blume (Croton), *Ricinus communis* L. (Castor bean), *Manihot ultissima* Pohl. (Cassava), *Impatiens balsamina* L. (Balsam), *Gossypium hirsutum* L. (Upland cotton), *Hibiscus esculentus* L. (Okra),[a] *H. rosa-sinensis* L. (Chinese hibiscus), *Hibiscus Viola floridana* Brainerd (Florida violet), *V. odorata* L. (English violet), *V. primulifolia* L. (White violet), *V. tricolor* L. (Pansy), *Carica papaya* L. (Papaya),[d] *Psidium guajava* Raddi. (Guava),[d] *Clarkia elegans* Dougl. (Clarkia), *Trachymene caerulea* R. Graham (Laceflower), *Ferula communis* L. (Giant fennel), *Limonium latifolium* Kuntze (Statice), *Anchusa officinalis* L. (Alkanet), *Myosotis scorpioides* L. (True Forget-me-not), *Heliotropium peruvianum* L. (Common heliotrope), *Verbena hybrida* Voss. (Verbena), *Lantana sellowiana* Link & Otto (Weeping lantana), *Salvia splendens* Ker. (Scarlet sage), *Mentha spicata* L. (Spearmint), *Solanum*

tuberosum L. (Potato),[a] *S. pseudo-capsicum* L. (Jerusalem cherry), *Salpiglossis sinuata* Ruiz & Pav. (Scalloped salpiglossis), *Schizanthus pinnatus* Ruiz & Pav. (Wingleaf Butterfly flower), *Digitalis purpurea* L. (Foxglove), *Linaria canadensis* (L.) Dumort (Toadflax), *L. floridana* Chapm., *Gerardia divaricata* Chapm. (False foxglove), *Plantago sp.* (Plantain), *Campanula medium* L. (Canterbury bells), *Lobelia erinus* L. (Lobelia), *Sonchus oleraceus* L. (Sow thistle), *Cichorium intybus* L. (Chicory),[a] *C. endivia* L. (Endive),[a] *Tragopogon porrifolius* L. (Salsify), *Lactuca sativa L. crispa* (Curled lettuce),[a] *L. sativa capitata* (Head lettuce),[a] *L. sativa longifolia* (Romaine lettuce), *Achillea millefolium* L. (Milfoil), *Chrysanthemum carinatum* L. (Annual chrysanthemum), *C. morifolium* Ram. (Florist's chrysanthemum), *C. parthenium* Pers. (Feverfew), *C. leucanthemum* L. (Ox-eye daisy), *Helianthus annuus* L. (Sunflower), *Bidens leucantha* (L.) Willd. (Spanish needle), *Cosmos bipinnatus* Cav. (Cosmos), *Dahlia pinnata* Cav. (Dahlia), *Coreopsis tinctoria* Nutt. (Calliopsis), *C. drummondii* Torr. & Gray (Goldenwave), *Callistephus chinensis* Nees. (China aster),[a] *Aster novae-angliae* L. (New England aster), *Erigeron sp.*, *Gaillardia pulchella* Foug. (Gaillardia), *Calendula officinalis* L. (Pot marigold), *Senecio cruentus* DC. (Cineraria), *Helichrysum bracteatum* Andr. (Strawflower), *Ageratum houstonianum* Mill. (Ageratum), *Centaurea cyanus* L. (Cornflower).

DISCUSSION

The host range of *Celery virus 1* as herein reported is not claimed to be complete. Other means of inoculation than those tried, applied to plants under varying conditions, might result in infection on hosts now considered immune from celery virosis. Both the aphid and leaf-rubbing methods of inoculation were very severe, and the basis of the selection of a number of the hosts used in the studies was their apparent occurrence as naturally diseased plants in the field. About one third of the hosts tested for susceptibility to *Celery virus 1* were successfully infected with the virus.

The celery virus was found to infect 4 monocotyledonous and 19 dicotyledonous families. The writer does not consider such a wide host range as being characteristic of *Celery virus 1* alone; indeed, it is possible that other viruses now believed to have a narrow host range, may, when studied under more variable conditions and with more variable technique, prove to have a host range as wide or wider than that described for the southern celery-mosaic virus. Grant (3) has recently extended the host range of ordinary tobacco-mosaic virus beyond a point that, a few years ago, would have been considered an impossibility.

With some viruses, *e.g.*, ring spot (12) and aster yellows (6), symptoms on a fairly wide range of hosts have many characteristics in common. Holmes (4) has shown that the effect of a single strain of a virus, ordinary

tobacco virus, on members of a single family of plants, the Solanaceae, may have great variableness in symptoms produced. In the present studies of *Celery virus 1* the extremes in systemic symptom expression have been found of remarkable range. So different are these symptoms on various hosts that in some cases, unless the whole history of the experiments were known, it would be hard to believe they were all produced by the same causative agent.

In some cases the development of primary lesions was dependent on leaf-rubbing inoculation, as in lamb's quarters, while in maize primary lesions did not occur unless aphids were used for inoculation purposes. In many other instances both methods of inoculation produced primary lesions. These lesions varied widely in character: Large black necrotic spots developed that involved the whole leaf, as in squash; diffuse lesions were produced on Datura, in some cases lesions appeared before systemic symptoms were evident, as in cucumber; in other instances lesions appeared after the systemic symptoms, as in tomato; there was the production of whitish lesions on the Phytolaccas, and the development of whitish lesions in phlox, which later recovered their chlorophyll and retained it when the rest of the leaf became yellow from age.

The symptoms of systemic infection were even more various than the phenomena exhibited by the symptoms of primary lesions. As examples may be cited the following: extreme blight and death of spinach, severe stunt of larkspur, stunt and mottle of Cocozelle squash, brilliant mottle and brown streak-like necrosis of celery, black necrosis and stunt of watermelon, severe stunt and rosette of banana, stunt and stripe of maize, medium mottle of tobacco, mild mottle and severe yellowing of snapdragon, mild mottle and severe stunt of tomato, brilliant yellow markings but very little stunting in Commelinas, escape of systemic infection by dropping of diseased leaves as in Datura, occasional masked symptoms of eggplant, and apparently consistent masking of symptoms in Floras paintbrush.

It is of special importance to vegetable growers that, with the exception of a few plants in one series of one variety of turnips, repeated attempts to infect as many members of the mustard and cabbage family as could be secured have failed to produce infection with *Celery virus 1.* The lettuce, endive, and chicory varieties also remained free from infection. Among the leguminous vegetable crops many varieties of garden beans, peas, soybeans, and field or cowpeas did not succumb to the virus. Irish potatoes were not susceptible to infection.

Varieties of rice, oats, and barley were tested for susceptibility to *Celery virus 1* but remained unaffected. A number of pasture and other grasses also remained free of infection.

It is well to understand that in many cases of susceptible hosts reported

in this paper apparent immunity may exist in the field. Under experimental conditions it is possible to force infection of certain hosts by the virus, either by confining aphids that would not ordinarily occur on them, or by the leaf-rubbing method, which may be a much more drastic means of transmittal than that occurring in nature. It is because of such reasons that data on natural field occurrence of diseased plants were particularly sought and recorded.

SUMMARY

The southern celery-mosaic virus (*Celery virus 1*) has been reported by the writer from certain portions of the subtropical United States (Florida), from the tropics (Cuba), and it is probable that it occurs in other subtropical and tropical regions. Results reported in this paper are largely from studies made in Florida.

Inoculation experiments, supplemented by symptom studies and field observations, have demonstrated that the southern celery-mosaic virus may infect at least 91 different host plants, comprising 4 families of the monocotyledonae and 19 families of the dicotyledonae. Of the susceptible host plants, 46 have been found naturally infected in the field. In addition to the 91 susceptible hosts mentioned, 146 species were tested and were apparently not susceptible to infection by *Celery virus 1*.

Some of the important 29 susceptible vegetable crops are: different types of celery, sweet corn, cucumber, ground cherry, sweet pepper, spinach, squash, and sweet potato. Some important vegetable crops that did not succumb to the virus infection are: different types of cabbage and mustard, garden and field beans, garden pea, lettuce, endive, and Irish potato.

Some of the important 23 ornamental hosts are: Aztec and French marigolds, Floras paintbrush, geranium, larkspur, periwinkle, petunia, and zinnia. Some of the important 14 susceptible weed hosts are: Crane's-bill, species of Physalis, pokeberrys, ragweed, wild wandering jew, and creeping day-flower. Some of the important 25 susceptible miscellaneous plants are: broadbean, bananas, varieties of sorghum, tobacco and other solanaceous species, wheat, and rye.

Extreme variability in symptoms was notable. Primary lesions resulted in certain cases from both aphid and rubbing methods of inoculation and systemic infection did not always follow primary-lesion development. Severe necrosis, stunting, yellowing, mottling, and distortion developed on some hosts, while in certain others these symptoms were mild, in some cases infected leaves were dropped, which precluded systemic disease, and masked carriers were noted in certain species of plants.

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WOJNOWICIA GRAMINIS AS A VERY WEAK, SECONDARY PARASITE OF WINTER CEREAL CROPS[1]

RODERICK SPRAGUE[2]

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INTRODUCTION

For a number of years after Heald (7) first reported finding the prairie foot rot of winter wheat near Spokane, Washington, two fungi that did not sporulate in culture were regularly isolated from the soil-line lesions of diseased wheat and barley culms[3] growing on certain high prairies in the Columbia Basin of Oregon and Washington. One of these fungi was identified by McKinney and Johnson (14) and McKinney (13) as *Wojnowicia graminis* (McAlp.) Sacc. and D. Sacc and the other by the writer as *Cercosporella herpotrichoides* Fron (21). In another article, the writer (18) briefly mentioned that, under experimental inoculation conditions, *Wojnowicia graminis* was a very weak parasite on winter wheat in Oregon, and all his studies conducted since have confirmed the original findings, namely, that the Cercosporella foot rot (Columbia Basin foot rot) is due to *Cercosporella herpotrichoides* and that *W. graminis* is a very weak secondary parasite.

DISTRIBUTION

Wojnowicia graminis is wide spread in Australia (3, 12, 15, 16), in the Pacific Northwest, and throughout the Great Plains area of North America. Kirby (10) reported *W. graminis* associated with *Ophiobolus graminis* Sacc. in grain in New York. Foëx (4), Foëx and Rosella (5, 6), and Kerleroux (9) found it associated with several fungi near Paris, France, and van de Laar (11) reported it from Holland. Probably it occurs in favorable localities throughout northwestern Europe.

Approximately 125 isolations of *Wojnowicia graminis* mentioned by Sprague and Fellows (22) were obtained from Cercosporella-infected culms of wheat and barley grown in various prairie areas in Wasco and Union

[1] Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Oregon and Washington Agricultural Experiment Stations with field headquarters at Corvallis, Oregon. Published as Technical Paper No. 229 of the Oregon Technical Series.

[2] Assistant pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture. The writer acknowledges the valued assistance of Dr. A. G. Johnson in preparing the manuscript for publication.

[3] Isolations made by Dr. Hurley Fellows during the years from 1923 to 1929 from wheat collected in Union County, Oregon, consisted predominantly of these two fungi. (Unpublished reports.)

Counties, Oregon, and Klickitat County, Washington. As reported elsewhere (19), *Cercosporella herpotrichoides* in the Pacific Northwest is restricted to sod-grass-prairie areas in foothills in the Columbia Basin where the average annual precipitation ranges from 15 to 25 inches. However, the range of *W. graminis* extends to some extent into semiarid portions of Wasco and Umatilla Counties, Oreg., and Asotin, Walla Walla, Columbia, Spokane, Whitman, and Klickitat Counties, Wash. In Asotin County it is abundant in the roots and crowns of Turkey wheat in fields several miles from the Cercosporella-infested area near Anatone. In Turkey wheat it is associated with a condition resembling the Helminthosporium foot-rot complex in the Great Plains area. *W. graminis* apparently thrives in the semiarid regions, where the average annual precipitation may range from as low as 12 inches to approximately 25 inches. Nearly all of the isolations have been made from wheat plants grown in various phases of fine or very fine sandy loam soils. *W. graminis* is associated with *C. herpotrichoides* in the basal culms of wheat growing in a mellow, dark soil near Anatone, Wash., which, according to Dr. W. L. Powers of the Oregon Experiment Station, is essentially the same as the black soil of Russia. In Walla Walla County *W. graminis* was isolated from almost 100 per cent of the culms of Hybrid 128 wheat, a winter variety, growing in Walla Walla series fine sandy loam in certain low swales. The fungus has not been found to date in the acid soils of humid western Oregon nor does it occur very regularly in heavy soils in the semiarid portions of the Pacific Northwest.

SYMPTOMS

Carne (3) states that *Wojnowicia graminis* causes a root rot on the wheat plant and produces partly superficial, dark brown to black spots and streaks on the culm. He says that the fungus seldom appears above ground on the outside of the culms. Foëx (4) states that *W. graminis* was isolated twice in the spring of the year at Versailles from wheat plants with superficial brown, circular spots extending from the second internode towards the lower internode.

In the Pacific Northwest the action of *Wojnowicia graminis* has been so closely associated with that of *Cercosporella herpotrichoides* that very few specific symptoms are recognizable. Besides this association with the recognized symptoms caused by *C. herpotrichoides*, *W. graminis* is associated with slight etching or superficial streaking of the basal parts of the culms and also to some extent with a certain type of browning of roots close to the crown. It also invades the central cavity of nearly ripe culms and causes them to take on a lead color for several inches above the ground. Sometimes, in late season, this condition extends beyond the zone attacked by *C. herpotrichoides* (Fig. 1). In Walla Walla County and north into

FIG. 1. Winter rye, in advanced soft-dough stage, from field near Imbler, Ore., showing Cercosporella lesions near soil line and extension of discoloration of culm for several inches above through action of *Wojnowicia graminis* after a heavy rain in late June, 1931. $\times \frac{2}{3}$.

Spokane County, Wash., *W. graminis* has been found to invade the central cavity of the culms of tall, nearly ripe wheat that did not show symptoms of Cercosporella foot rot.

HOST RANGE

Wojnowicia graminis has been isolated from the following fall-sown grains and grasses grown under natural conditions in the field: Winter

wheat, *Triticum vulgare;* emmer, *T. dicoccum;* einkorn, *T. monococcum;* spelt, *T. spelta;* barley, *Hordeum vulgare;* rye, *Secale cereale;* winter oats, *Avena sativa;* bunch grass, *Agropyron inerme* and *A. riparium;* and cheat grass, *Bromus tectorum; Koeleria cristata;* and *Poa sandbergii.* All of the grass hosts were found in one location in Spokane County, Wash., except *B. tectorum,* and in all these cases of grass hosts the fungus was associated with *Cercosporella herpotrichoides. Wojnowicia graminis* does not occur commonly on oats and einkorn. Pycnidia of *W. graminis* were found only on winter wheat. On all the other hosts the fungus was isolated and identified by the vegetative mycelium. No attempt was made to study the fungus in the spring-sown grains.

INOCULATION STUDIES

While the foot rot ascribed to *Wojnowicia graminis* has been recognized as a serious problem in Australia for many years (3, 12, 15, 16) apparently no critical study was made to determine the relative pathogenicity of this and other fungi until recently. Correspondence with W. V. Ludbrook, Division of Plant Industry, at Canberra City, Australia, who very kindly furnished the writer two representative pure cultures of *W. graminis,* indicates, however, that this neglected phase is being studied and that the former supposition that the organism was highly pathogenic is now in considerable doubt.

McKinney (13) stated that *Wojnowicia graminis* was only slightly pathogenic to wheat seedlings and suggested further studies. Heald (8) mentioned inoculating winter wheat with pure cultures of the fungus obtained both locally and from Hurley Fellows. The writer, as an undergraduate student, assisted F. D. Heald at the time in this experiment and recalls that the results at best indicated only weak pathogenicity for *W. graminis.*

Broadfoot (2) recently reported that *Wojnowicia graminis* obtained from 6 localities in Alberta Province did not cause seedling injury. His studies were conducted as pot cultures in the greenhouse.

In 1929 germinating wheat was grown at Corvallis on sterile quartz sand saturated with nutrient broth in bottles and on potato dextrose agar in flasks, and inoculated with several strains of *Wojnowicia graminis.* One group was incubated at 15° C. and another group at 20° C. In the quartz sand there were 3 cases out of 8 at 15° C., where the fungus invaded through the edge of the leaf sheath for a short distance at points where the sheath came in contact with the spreading fungus colony. The lesions failed to spread beyond the initial development. The wheat in all other bottles and flasks, including all uninoculated controls, remained healthy.

In the field, on Tygh Ridge, Oreg., 16-foot rows of Hybrid 128 wheat,

sown August 29, were inoculated in duplicate with 3 separate strains of *Wojnowicia graminis* isolated from Cercosporella-infested wheat from Klickitat County, Wash., and Union County, Oreg. The wheat on Tygh Ridge, which was in a noninfested field, free of any natural infestation with *Cercosporella herpotrichoides,* and 2 miles from the nearest infestation, was commercially seeded in early September and inoculated with *W. graminis* on October 10, 1929. Viable inoculum, which was grown in liter flasks on sterile seed of oats and barley, was applied at the base of the crowns and covered with an inch of moist soil. The inoculum was applied at approximately the rate of ½ liter per rod row. Additional inoculum was scattered over the plants. In April, 1930, the outer leaf sheaths of the inoculated plants were brown and decayed and pycnidia of *Wojnowicia graminis* were protruding from the sheaths. The injury was, however, only one sheath layer deep and the plants were otherwise as normal as the uninoculated plants that surrounded the inoculated portion. This experiment on Tygh ridge was in the same field with that reported earlier (21) for Cercosporella in which the wheat inoculated with *C. herpotrichoides* under the same conditions was severely injured.

Essentially the same type of experiment was continued on High Prairie, Klickitat County, Wash., in the winter and spring of 1930–31 with the same results, except that *Wojnowicia graminis* failed to produce pycnidia. There were faint etchings on the culm of the inoculated plants, but isolations yielded only *Fusarium culmorum* and *Fusarium* spp. but not *W. graminis.*

In the field at Corvallis, Oreg., duplicated rod rows of Huston, Holland, and Purplestraw wheat, growing in Newberg sandy loam, were inoculated on December 23 at seeding time (dry fall prevented earlier seeding) as in the above reported experiments. There was very slight injury to a few crowns but the injury was negligible as compared to the destruction wrought by *Cercosporella herpotrichoides* in a nearby plot under the same inoculation conditions (21).

In the greenhouse at Corvallis miscellaneous inoculation series have been conducted from time to time during the 6-year period from 1929 to 1934. The conditions in the greenhouse were as follows: No heat was used and the humidity was kept as high as possible, which, during the mild, moist winters, that prevail at Corvallis, gave nearly ideal growing conditions for most cereal foot-rot fungi that were being studied. At first the inoculated plants were grown in deep flats but, since 1929, they have been grown either in soil in the bench or in cubical fir boxes that have a capacity of approximately one cubic foot. Newberg fine sandy loam was used unsterilized, as it was free from *Wojnowicia graminis.* Most of the inoculations were made on club hybrid wheats (Hybrid Nos. 63, 128, or 143) at seeding time or

several weeks after emergence. In addition, inoculations were made on white winter barley, rye, *Agropyron spicatum*, *Festuca ovina*, *Agropyron tenerum*, *A. cristatum*, and *Bromus rigidus* with practically negative results. These experiments totalled about 3,000 inoculated culms. No exact culm or plant counts were made on some of the experiments. In all of them the usual etchings and occasional saprophytic stromatic growth were noted in a small percentage of the culms, the rest being apparently healthy. Positive isolations were obtained from some of the wheat culms that showed superficial injury.

The results of inoculation with the two Australian strains and one Oregon strain (J. J. 1.) are given in table 1. Reisolations were attempted from representative lesions of all hosts and were positive only in 2 out of 10 from wheat, 6 out of 10 from rye, and 13 out of 15 from barley. The results indicated, as in previous studies, that *Wojnowicia graminis* does little damage to most cereals. In the case of white winter barley the total weight of the 4-foot row inoculated with Australian culture No. 8/248 was 23.2 grams and the uninoculated check 58.5 grams. However, in 10 of the 16 rows inoculated with the Australian cultures, the yields from the uninoculated rows weighed more than those from the controls, and the grand total yield for the 16 inoculated rows was 1,556.7 grams, and that for the inoculated ones was 1,516.4 grams. Apparently, therefore, *W. graminis* is almost of no economic importance, except possibly on barley and rye.

TAXONOMY

The genus Wojnowicia Sacc. (17) differs mainly from Hendersonia Berk. in having blunt setae or hairs present on the pycnidium. The long, curved, spindle-form spores described for the several species of Wojnowicia on Gramineae have their counterpart in several nongraminicolous species of Hendersonia, such as *H. peponis* Rolland or *H. fusariodes* Sacc. as illustrated by Allescher (1). While it is apparent that the genus Hendersonia, as now interpreted, needs critical study, the spores of Wojnowicia fall within the limits of Hendersonia, and, in final analysis, the hairs on the pycnidium of Wojnowicia constitute the only difference between the two genera. The writer questions the original necessity of erecting the genus Wojnowicia, but he prefers to retain for the present the now recognized name of *W. graminis*. The writer wishes to point out further that the described species of Wojnowicia and Hendersonia on Gramineae should be studied to determine synonomy. He suspects, but is not in position to obtain type materials, that most of the species of these genera described on grasses and cereals belong to a single, somewhat variable species.

Table 2 lists a number of these suspects with the spore measurements of the types given where known.

TABLE 1.—*Result of inoculating in the greenhouse various grains and grasses seeded October 19, 1933, with wheat-grain cultures of Wojnowicia graminis. Inoculated December 18, 1933. Plants dug and results recorded at or near heading time March 27, 1934*

Grain or grass inoculated	Number of plants with or without lesions											
	Inoculated with Oregon culture		Not inoculated		Inoculated with Australian culture 211		Not inoculated		Inoculated with Australian culture 8/248		Not inoculated	
	Lesions slight	Healthy	Lesions slight	Healthy	Lesions slight	Healthy	Lesions slight	Healthy	Lesions slight	Healthy	Lesions slight	Healthy
Fulhio wheat	0	71	0	80	0	43	0	57	0	81	0	54
Holland wheat	4	65	3	68	6	32	3	27	8	24	0	31
Huston wheat	0	69	0	81	3	41	0	61	0	39	0	47
Golden wheat	0	70	0	66								
White Winter barley	2	99	0	105	24	71	7	70	45	47	0	89
Winter rye	18	67	0	86	5	31	6	36	0	38	0	19
Bearded Winter spelt	2	91	0	102	0	85	0	135	8	68	0	84
Winter Turf oats	0	83	0	18	0	87	0	95	0	91	0	82
Kanota oats	0	91	0	24	0	73	0	91	0	79	0	102
Agropyron spicatum	0	64	0	41								
Poa sandbergii	1	43	0	31								
Bromus rigidus	0	118	0	96								

TABLE 2.—*Species of Hendersonia and Wojnowicia on Gramineae, which have spore measurements approaching those of Wojnowicia graminis (McAlp.) Sacc. and D. Sacc.*

Fungus	Host	Year described	Spore size	Spore septation
			μ	
Hendersonia herpotrichia Sacc. (Pycnidial stage of *Ophiobolus herpotrichus*)	Gramineae	1883	36 × 6	8
H. hirta Schroet.	*Setaria verticillata*	1890	24–28 × 3–4	7
Wojnowicia hirta (Schr.) Sacc.				
W. tenella Pat.	Gramineae	1897	25–26 × 4	7
H. graminis McAlp.	Wheat	1904	32–38 × 4–5	7
W. graminis (McAlp.) Sacc. and D. Sacc.				
H. secalina Died.	Rye	1914	25 × 5	7
Angiopomopsis lophostoma Hoehn. *W. lophostoma* (Hoehn.) Sacc.	Phragmites	1912		

The mean spore size of *Wojnowicia graminis* varies somewhat. McKinney illustrated, by photomicrograph, spores measuring 24–36 × 2.4–3.6 μ. The measurements made by the writer (50 spores samples) are of slightly broader spores. One field-grown, naturally inoculated sample (Waseo County, Oregon) averaged 29–36 × 4.6–5.7 μ; another, from artificially inoculated field material averaged 37.9 × 4.9 mean spore size (31–46 × 4.2–7.2 μ) and spores on an oat-barley-grain culture measured 26.4–39.6 × 3.2–5.4 μ. Van de Laar (11) reported pycnospores 29.58 × 3.47 μ and Broadfoot (2) gave 26.3–43.8 × 2.5–5.6 μ with a mean spore size of 36 × 3.9 μ. In general, specimens from Europe have somewhat smaller spores than those from the Pacific Northwest or from Australia. Those from Europe approach in size those of *Wojnowicia hirta* (Schr.) Sacc. Considering spore measurements alone, however, there is doubtful specific difference between any of the species listed in table 2.

Besides morphological differences, *Wojnowicia graminis* is a complex of physiologic forms that vary slightly, one from another, in rate and type of growth on potato-dextrose agar and on wheat-grain cultures and also in pigmentation and crystalline precipitates in potato-dextrose agar. The majority of the cultures associated with *Cercosporella herpotrichoides* were nearly identical in appearance, except for variations in substratum color (bright lemon, orange or rosaceous) but the isolates from the grasses and

those from wheat from the semiarid parts of the Columbia Basin free from *C. herpotrichoides* showed at least four more or less distinct strains. The strains from Australia were similar to strains isolated from wheat in Oregon. One of Dr. Ludbrook's cultures, namely, No. 8/248, he reports (in correspondence) is exceptional in that it fruits readily in pure culture. The usual paucity of fruiting agrees with the writer's findings in Oregon. In 1929–30, the writer made more than 150 isolations from wheat and grasses collected in Oregon and Washington. These cultures, on potato-dextrose agar, were kept for months at 15° C. and only one culture was found to be sporulating, which indicates the meagerness of sporulation under these conditions. A few cultures on potato-dextrose agar, however, have sporulated regularly (Fig. 2) when kept at 3.3° C. in an electric re-

FIG. 2. Potato-dextrose agar culture of *Wojnowicia graminis*, isolated from wheat in Oregon, showing pycnidia. ×1⅓.

frigerator. Furthermore, the fungus has been found to sporulate readily on sterile wheat heads, wheat kernels, or a mixture of barley and oats kernels when kept out of doors. In such cultures the fungus produces spores both in pycnidia and in acervuli. Corn meal also has proved to be a good medium for inducing sporulation.

DISCUSSION

Within recent years several of the fungi long recognized as severe foot-rot parasites of winter cereals have been shown to be less active than formerly thought, and other fungi, either unknown or obscurely known, have replaced them in part. *Wojnowicia graminis* is clearly one that has been overrated and should be listed among the weaker parasites. There is still need for exact study of this and other fungi in the rôle of weaker assisting companions to other much more active parasites. Inoculation studies with mixtures of pure cultures of *W. graminis* and *Cercosporella herpotrichoides* are in progress in Oregon. Preliminary observations indicate that *W. graminis* does not appreciably increase the damage done by *C. herpotrichoides*.

The complex studied by Foëx and Rosella (4, 5, 6) and coworkers, by Fellows and the writer (18, 19, 20, 21, 22), and by van de Laar (11) indicate the relative pathogenicity of the several fungi, which are sometimes associated, as follows:

Active parasites:	*Ophiobolus graminis* and *Cercosporella herpotrichoides*
Weak parasites:	*Ophiobolus herpotrichus* and *Leptosphaeria herpotrichoides*
Very weak, secondary parasite:	*Wojnowicia graminis*

SUMMARY

Wojnowicia graminis (McAlp.) Sacc. and D. Sacc, is a species with a number of physiologic forms or strains, with some varieties in morphological characteristics, and is very weakly pathogenic on a number of cereals and grasses.

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ASCOCHYTA BOLTSHAUSERI ON BEANS IN OREGON

RODERICK SPRAGUE

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INTRODUCTION

Ascochyta boltshauseri Sacc. was found on snap beans (*Phaseolus vulgaris*) near Astoria, Oregon, in September 1932, apparently its first reported occurrence in the United States. Through the courtesy of Dr. F. P. McWhorter of the Oregon Agricultural Experiment Station the material was given to the writer for studies supplemental to earlier reported work on leguminous Ascochyta species (7, 8, 11, 12).[1]

PURE CULTURE STUDIES

The initial growth on potato-dextrose agar was grey and felt-like, which gradually changed to a mottling of greys and fluffier buff areas. The mature colonies somewhat resembled those of *Ascochyta pisi* Lib. from *Vicia villosa* (12).

HOST RANGE STUDIES

Pot-grown, 3-weeks-old seedlings were inoculated with spore suspensions from pure cultures and incubated in spray chambers, as previously described (12). The data in table 1 is from an unpublished portion of the manuscript of experimental studies made at the University of Cincinnati between 1926 and 1929 (11) with O. T. Wilson as faculty adviser. In this work neither *Mycosphaerella pinodes* (Berk. and Blox.) Stone, nor any of the physiologic forms of *Ascochyta pisi* were able to attack *Phaseolus vulgaris*. *P. aconitifolius* and *P. aureus* were slightly susceptible to *M. pinodes* and to *A. pisi* isolated from pea (*Pisum sativum*) and *A. pinodella* (from pea).

Table 2 summarizes inoculation studies conducted at Corvallis, Oregon, with the Ascochyta from beans collected at Astoria. The plants in this instance were 8 weeks old. *Phaseolus* spp. only were susceptible to the Ascochyta from beans, although there was some slight etching on the leaves of peas. Reisolations, however, were negative in the case of the pea.

Symptoms began to appear on the inoculated beans at Corvallis at the end of 5 days, well-formed lesions were present 2 days later, and pycnidia with maturing spores 3 days after that.

[1] Credit for first distinguishing *Ascochyta pisi* Lib., *A. pinodes* L. K. Jones and *A. pinodella* L. K. Jones from each other belongs to M. B. Linford and F. R. Jones who were aware of the difference for some time before any published data, the first of which was published by Linford in The Canning World (7). L. K. Jones later confirmed this work and rounded out the studies.

TABLE 1.—*The results of inoculating Phascolus spp. with various Ascochyta spp. and Mycosphaerella pinodes at Cincinnati, Ohio (1926–1929). Plants were inoculated with pycnospore suspensions and incubated in a spray chamber. All noninoculated check plants were healthy. All plants were grown in six-inch clay pots*

Technical name of host	Common name of host	Results, Positive (+) and Negative (−) by number of pots									
		A. pisi (pea)[a]		*M. pinodes* (pea)		*A. pinodella* (pea)		*A. pisi* (Vicia faba)		*A. pisi* (V. villosa)	
		+	−	+	−	+	−	+	−	+	−
Phaesolus aconitifolius	Moth bean	1	2	2	0	2	1	0	1	0	0
Phaseolus angularis	Adzuki bean	0	3	0	3	0	2	0	3	0	0
P. aureus	Mung bean	3	1	2	0	3	1	0	1	0	0
P. calcaratus	Rice bean	0	2	0	3	0	4	0	1	0	0
P. lunatus	Sieva bean	0	4	0	2	0	3	0	3	0	0
P. limensis	Lima bean	0	3	0	1	0	1	0	2	0	0
P. mungo	Urd bean	0	4	0	3	1	1	0	1	0	0
P. coccineus	Scarlet runner bean	0	4	0	2	0	2	0	2	0	0
P. vulgaris	Black valentine snap bean	0	3	0	2	0	3	0	3	0	0
P. vulgaris	Red Mexican field bean	0	3	0	3	0	0	0	2	0	3
P. vulgaris	Lazy wife snap bean	0	3	0	3	0	1	0	1	0	1
P. vulgaris	Refugee snap bean	0	3	0	2	0	1	0	0	0	0
Total		4	35	4	24	6	20	0	20	0	4

[a] The name in parenthesis refers to the host from which the inoculum was originally isolated. *A. pisi* from pea was isolated from a diseased pod from Ohio, *M. pinodes* from Wisconsin seed, *A. pinodella* from Wisconsin, *A. pisi* from nine year old *V. faba* seed from California and *A. pisi* from *V. villosa* leaf spot, Pullman, Wash.

MORPHOLOGY

The morphological characters of the material of *Ascochyta boltshauseri* from Astoria is as follows: pycnidia numerous, obscure, light brown to dark brown (on pods) 120 to 150 μ in diameter; pycnidia on inoculated leaves golden brown, 60 to 130 μ in diameter. Spores, on pods, predominately one-septate (many immature), 15 per cent to 20 per cent of the spores were 2- to 5-septate, mostly 2-septate; one septate spores 10–27 × 2.5–6.6 μ, mean spore size 18 × 4.5 μ; multiseptate spores 16.6–34 × 4.5–7.1 μ, mean spore size 21.5 × 5.6 μ; spores in pure culture on potato-dextrose agar mostly non-septate, constricted in 2 or more places, 6–11 × 2–3 μ, a few much larger; spores on lesions from artificially inoculated leaves the same size as on pods of naturally inoculated material.

TAXONOMY

While certain forms of *Ascochyta pisi* approach in spore size those of *A. boltshauseri* the two are separate species as they have entirely distinct

TABLE 2.—*The results of inoculating various legumes at Corvallis, Oregon, with Ascochyta boltshauseri on May 1, 1933, and incubating in a spray chamber until May 11, 1933. All noninoculated check plants were healthy. Water temperature 10–14° C.*

Technical name of host	Common name of host	Results, Positive (+) or Negative (–)						
		Number of pots of plants		Number of plants		Number of leaves		Relative severity
		+	–	+	–	+	–	
Phaseolus vulgaris	Red valentine bean	2	0	2	0	16	0	Moderate
	Boston navy bean	2	0	8	0	36	2	Slight+
	Bush black valentine bean	2	0	9	0	42	0	Severe+
P. aureus	Mung bean	2	0	6	0	25	0	Dying
P. angularis	Adzuki bean	2	0	9	0	42	0	Moderate
P. coccineus	Scarlet runner bean	2	0	9	0	51	4	Severe+
Pisum sativum var.	Alaska pea	2	2	4	7	6	105	Trace (?)
	Blue Prussian field pea	0	2	0	9	0	136	
Vicia villosa	Hairy vetch	0	2	0	21	0	460	
Vicia sativa	Common vetch	0	1	0	19	0	560	
Medicago sativa	Grimm alfalfa	0	2	0	39	0	218	
Trifolium repens	White clover	0	1	0	19	0	540	
Lathyrus odoratus	Sweet pea	0	2	0	10	0	112	

host ranges and the dark to drab zonate lesions of *A. boltshauseri* are entirely distinct from the light-colored red-bordered spots of *A. pisi*. The wide difference in spore size and distinct host range alone are sufficient to separate *A. boltshauseri* and *M. pinodes*.

Stagonopsis phaseoli Eriks. is sometimes reported as a parasite of beans in Europe. The type, as examined by the writer (Fungi par. scan. 377), has spores averaging 19.5×5.9 μ and the symptoms are identical with those of *A. boltshauseri*. The two fungi are unquestionably identical. *Stagonopsis phaseoli* was described in a publication appearing Sept. 9, 1891 (5). The description of *A. boltshauseri* appeared in Heft 3 of the Zeitschrift für Pflanzenkrankheiten of 1891 (1). While Boltshauser-Amrisweil dated his article June 27, 1891, there is no apparently possible source of information on when this article actually appeared. The present editor of this journal, Dr. Tubeuf, says in answer to a letter of inquiry by the writer, *Heft 3 ist nominell zwischen 1 Mai u. 1 Juli, in Wirklickheit nahrscheinlich etwas verspätet, aber doch in Laufe des Juli 1891 erschienen.* While there may be some question as to whether the article, signed June 27, appeared as early as July it is reasonable to assume that it appeared some time before Eriksson's did. Inasmuch as Saccardo's name is generally accepted the writer prefers to retain it until definite proof is advanced that Eriksson's article appeared first.

The work of Diedicke (3, p. 142, 4 pp. 388–389, 397–400) in proposing *Stagonosporopsis boltshauseri* (Sacc.) Died. and of Petrak in making the combination *Stagonosporopsis hortensis* (Sacc. and Malbr.) Petrak (9) is not acceptable to the writer, as he considers Stagonosporopsis Died. as invalid (12). Since the most common condition of mature material of this fungus is that of an Ascochyta, the writer considers that it should be assigned to that genus.

The type material of *Stagonospora hortensis* Sacc. and Malbr. is not available. The original description (10) states that the spores are 4-guttulate, finally 3-septate, hyaline, and measure 18–27 × 7 μ. The writer suspects that this fungus might be the same as *A. boltshauseri* but on account of not having type material of *S. hortensis* he hesitates to follow Petrak's lead. There is no indication in Petrak's work (9) that he saw the type of *Stagonospora hortensis.*

Stagonospora phaseoli Dearness (2) is distinct from *Ascochyta boltshauseri.* Type material furnished by Prof. Dearness had light-colored, red-bordered lesions and typical multiseptate Stagonospora spores.

The synonomy of *A. boltshauseri* is as follows:

Ascochyta boltshauseri Sacc. Midsummer 1891

Syn.

Ascospora pisi Fuckel 1869 (6)

Stagonopsis phaseoli Eriks. Sept. 9, 1891

Stagonosporopsis boltshauseri (Sacc.) Died. 1912

Stagonosporopsis hortensis (Sacc. and Malbr.) Petrak 1921

SUMMARY

1. A collection of *Ascochyta boltshauseri* Sacc. on snap beans (*Phaseolus vulgaris*) was made near Astoria, Oregon, in 1932, apparently the first report of this disease in North America.

2. Cross inoculation studies showed that *A. boltshauseri* was distinct from other Ascochytae on legumes.

3. *Ascochyta boltshauseri* and *Stagonopsis phaseoli* Eriks. which have been considered two distinct diseases are synonymous. Since Eriksson's description apparently appeared a few weeks later than that of *A. boltshauseri* the latter name is retained.

4. The need for comparative study with *Stagonospora hortensis* type material is pointed out. The invalidity of the genus Stagonosporopsis Died. is again mentioned.

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RELATION OF SOIL ACIDITY TO A SEEDLING DISEASE OF ALFALFA ON THREE IOWA SOILS[1]

WALTER F. BUCHHOLTZ

(Accepted for publication October 26, 1934)

In 1933 a high correlation between soil acidity and a damping-off disease (Pythium species) of sugar beets was noted in certain fields in northern Iowa. At the same time similar acid soils were observed to yield poor stands of alfalfa. These observations brought to mind the diverse explanations for failures of alfalfa seedings on acid soils and suggested the possible importance of damping-off fungi. In order to determine this rôle of damping-off fungi, trials were started with alfalfa on acid (pH 6.2) and neutral (pH 6.8 to 7) samples of Webster silt loam under greenhouse conditions. The alfalfa seedlings in acid soil showed symptoms similar to those induced on sugar-beet seedlings by species of Pythium. Some embryos were invaded and reduced to a gelatinous consistency before they had broken the seed coat. Others were killed before they emerged above the soil line. Easily visible mycelium extended from these dead plants to the surrounding soil particles. When the few plants that did emerge made their appearance above the surface of the soil, they were already infected. The first noticeable symptom on these plants was a collapse of the primary root and the lower portion of the hypocotyl. They quickly became flaccid, wilted, and died.

On neutral soil in the greenhouse the general effect was much less severe. Several pots of seedlings were grown apparently free from invasion by Pythium. Infection, when it occurred, very seldom if ever took place before the seedlings emerged from the soil, and even then a large percentage escaped.

In the field the effect was not quite so severe on either acid or neutral soil. On acid Webster silt loam, a few of the seedlings were killed before emergence. Some were attacked just as they emerged. Here again the first noticeable symptom was the collapse of the infected tissues of the hypocotyl and primary root. In young seedlings, invasion apparently was very rapid and general so that the upper hypocotyls were cut off from a moisture supply and under dry conditions the plants wilted and died in less than 24 hours.

On seedlings infected when older, parasitic invasion seemed restricted and the amount and rate of necrosis less extensive. The hypocotyl and primary root and sometimes the secondary roots were partially or com-

[1] Journal paper No. J189 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 77.

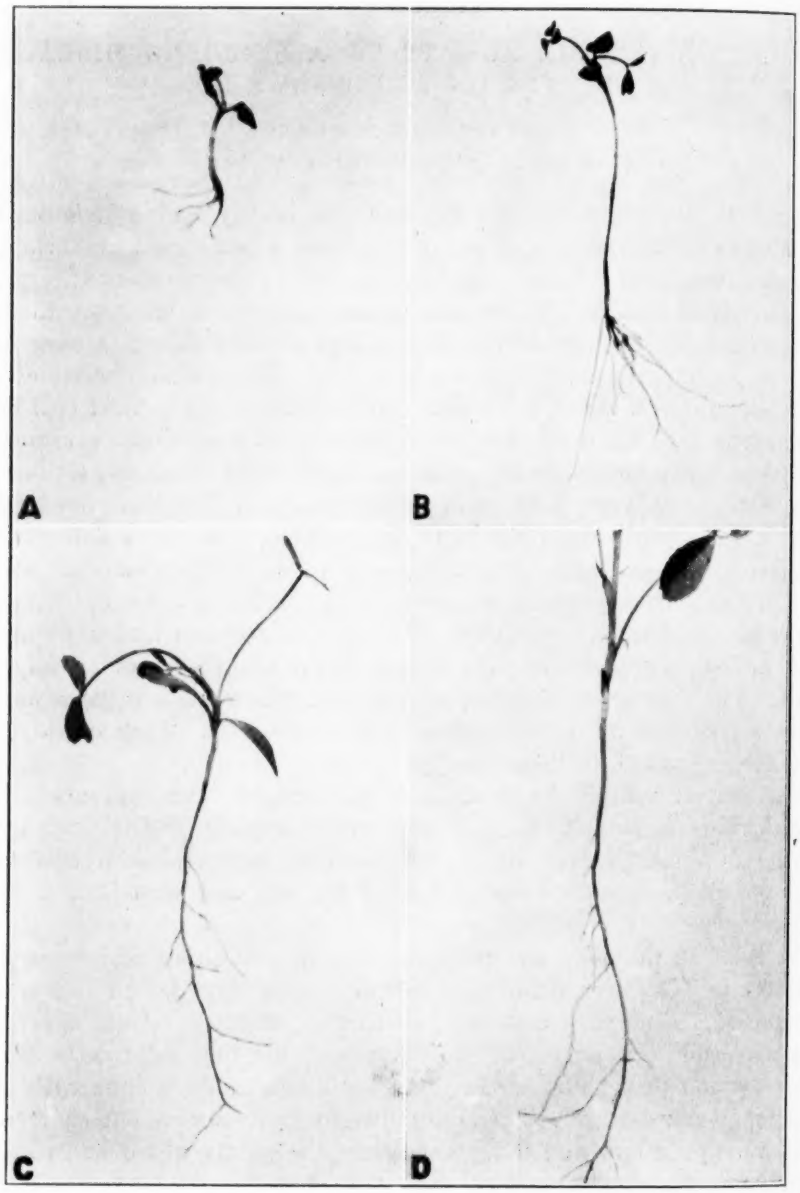

FIG. 1. Alfalfa seedlings 3 weeks old grown on acid Webster silt loam, showing different types and degrees of injury by damping-off parasites. A. Seedling with primary root and lower hypocotyl rotted off when small. B. Larger seedling with primary root and 3 branch roots rotted off; in each case one or more branch roots have arisen from living tissues above the lesion: there is also a cortical lesion on the hypocotyl. C. Cortical lesion on the primary root and lower hypocotyl of a larger seedling; infection apparently occurred later than in A. D. A healthy seedling. ×1.

pletely girdled (Fig. 1; A, B, C). Frequently the tip of a primary root had been destroyed and several branch roots had grown out from the healthy tissue above (Fig. 1; A, B). Primary roots of diseased seedlings produced fewer secondary roots than did those of healthy seedlings. These older seedlings persisted, even though they were less vigorous than healthy ones. The first symptoms quickly disappeared as the collapsed cells of superficial lesions turned brown and disintegrated. As a result of such exposure, the remaining central portions of the axes appeared rough and desiccated.

All these symptoms occurred on plants grown on neutral Webster silt loam in the field, but to a lesser degree and in a smaller number of cases. On this neutral soil 6.4 per cent of the small seedlings died, as compared to 16 per cent on acid soil in the same plot. Since these plantings were not dug, the above figures do not include the plants that might have had lesions but were not killed immediately. On Clarion loam, where seedlings that were killed in early stages were not counted, only 59 per cent of the plants remaining on acid soil were healthy 5 days after emergence, whereas, on neutral soil in the same field under the same conditions, 93 per cent of the remaining plants were healthy. On acid Tama silt loam, about 2 weeks after emergence, only 52 per cent of the remaining plants could be classified as healthy and some of these were doubtful. To date it has not been possible to follow alfalfa seedings through to the first cutting and record continuous differences on acid and neutral soils, but comparative stand counts have been made on soils of different degrees of acidity. These counts show that acid soils have thinner stands than do neutral soils. A field seeding of alfalfa at Kanawha, Iowa, had an average of 7.1 plants per square foot on soil with a lime requirement of one and one-half tons per acre as compared to 12.3 per square foot on neutral soil. A field in Jones county on acid Clinton silt loam had one of the better stands in the neighborhood with only one plant per square foot. In 2 fields of alfalfa on one farm in Mitchell county stands were satisfactory only on naturally neutral soil, even when some lime had been applied to both neutral and acid areas.

The cultures isolated from recently collapsed tissues of infected seedlings appear to be species of the genus Pythium. Their young mycelium branches freely, is nonseptate, relatively hyaline, and from 1.5 to 3.5 μ in diameter. Older mycelium is larger and septate and devoid of protoplasm. Spherical hyaline conidia or sporangia, 18 to 34 μ in diameter, are borne terminally on branches of the mycelium. Intercalary ellipsoid conidia are about the same size. Zoospore formation has not been observed and oöspores have not yet made their appearance on artificial culture media. Recently infected material yields a high percentage of cultures on potato-

dextrose agar with ordinary seedling isolation technique. A delay of 24 hours after the appearance of initial symptoms often results in a poor yield. Very young infected seedlings sometimes dry up in 3 to 6 hours. Whether or not all the cultures obtained are of one species has not been determined, but it is felt that they are a rather homogeneous group. It is also believed that the same parasite or parasites that attack alfalfa will attack beets and other crops in the same soil. Beets that were planted alongside of alfalfa on Webster silt loam, Clarion loam, and Tama silt loam exhibited disease symptoms similar to those on the alfalfa, and isolation trials from diseased beet seedlings yielded cultures of Pythium similar in growth habit and conidia production to those obtained from alfalfa. When planted in the greenhouse on acid Webster silt loam on which sugar beets are severely diseased in the field, alfalfa, yellow sweet clover, red clover, alsike clover, white Dutch clover, *Lespedeza* sp., *Dalea* sp., and sugar beets all damped off and yielded cultures of similar pythiaceous fungi upon isolation. In the field on this soil the disease has been noted on red clover, sweet clover, alsike, and flax in addition to alfalfa and sugar beets, and successful isolations of similar fungi have been recorded from field specimens of all these except sweet clover.

Acid Webster silt loam, when steamed for 2 hours at 15 pounds, will grow a higher percentage of healthy alfalfa seedlings than will neutral soil not steamed. An application of 50 cc. of 0.5 per cent formaldehyde in a 4-inch pot will produce results similar to those noted on steamed soil. Limestone applied abundantly to this acid soil in the greenhouse has inhibited damping-off of alfalfa. Hydrated lime dusted on the seed has repeatedly given the same results with sugar beets.

In the accompanying table is a sample of the kind of results obtained by placing pots of alfalfa and alsike-clover seedlings at two temperatures, one below, the other near the optimum for the growth of Pythium in pure

TABLE 1.—*Results obtained from pot cultures of alfalfa and alsike-clover seedlings at two temperatures, one below, the other above the optimum for Pythium in pure culture*

Soil: Webster silt loam	Alfalfa				Alsike			
	20–25° C.		9° C.		20–25° C.		9° C.	
	H[a]	D[b]	H	D	H	D	H	D
Acid soil (pH 6.2)	1	28	28	30	93	30	132	23
Acid soil steamed (pH 6.4)	152	0	159	0	139	0	141	0
Neutral soil (pH 6.8–7.0)	96	34	106	8	148	0	134	0

[a] H = healthy. [b] D = diseased.

culture. Both these legumes emerged in larger numbers at the lower temperature and a higher percentage of the emerged plants were healthy. Steamed acid soil yielded a healthy stand of what was probably the maximum number of seedlings that would grow from the 200 seeds planted. While not entirely free from infection, the number of plants obtained on neutral soil approached the maximum and there was only a small increase in number of healthy plants on neutral soil at the lower temperature. In the greenhouse, alsike repeatedly has given a higher percentage of healthy plants on acid Webster silt loam than has alfalfa. Alsike is considered a better acid-soil legume than alfalfa. The symptoms on alsike and isolations from infected alsike plants were similar to those of alfalfa.

SUMMARY

It has been established that what appears to be Pythium species attacked germinating, emerging, and young growing seedlings of alfalfa on 3 acid Iowa soils in greater numbers and with greater damage to individual plants than on 2 similar neutral soils. The same disease has been found in the field on sugar beets, other legumes, and flax. It has also been determined that at 9° C. young alfalfa and alsike seedlings damped off less than at 20–25° C. Steaming and formaldehyde treatment enabled alfalfa and alsike seedlings to establish stands of healthy plants on acid soil as large or larger than those established on undisturbed neutral soil. The same effect to a limited degree was brought about by hydrated lime dusted on sugar beet seed and in one alfalfa planting by limestone, generously applied to the soil.

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CYTOLOGY OF SECONDARY SPORE FORMATION IN GANODERMA

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(Accepted for publication September 29, 1934)

In 1919 White (9) recorded that there was not a single instance of conidia or secondary spore formation from any part of the sporophore of *Ganoderma applanatus* (Pers.) Wallr. But I have observed that usually at the end of the rainy season (in October and November) the basidia of *G. lucidus* (Leyss.) Fr. and *G. applanatus* (Pers.) Wallr. are gradually succeeded by tramal-hyphae elongations within the pore tubes, which ultimately bear at their summit asymmetrically secondary spores that are indistinguishable from ordinary basidiospores in shape, size, and ornamentation of the spore walls. Buller (3, p. 202) would rightly call them secondary basidiospores, as, like basidiospores, they are asymmetrically situated on the end of the stalk and are shot away by the drop-excretion mechanism. To start with, after the rains a number of white hyphal projections bearing 2 conjugate nuclei with distinct clamps are found here and there amongst the basidia, some of them are almost uniformly narrow (Fig. 1, *a*), others have sickle-shape hyphae or straight broader hyphae at the base with narrow hyphae at the top (Fig. 1, *b–d*), bearing a number of clamps; the sickles are almost as long as basidia but are much narrower (about one-fourth the breadth of the basidia), they might be regarded as intermediate between basidia and tramal hyphae. These tramal-hyphae projections are then surmounted by very small rudimentary spores that gradually enlarge and assume the form and color of mature basidiospores. Finally, the basidia are hardly seen, the pore tubes show a large number of tramal-hyphae projections bearing secondary spores at their summit. Such tramal-hyphae projections with secondary spores in large numbers I have seen also in cases of *Trametes latinea* Berk. and *Polyporus calcuttensis* Bose collected in November and December, 1931, and of *P. orchroleucus* Berk. during the abnormally dry period of August, 1934. From the first-named one, *i.e.*, *T. lactinea*, I could get copious spore discharge within an agar plate, though there was not a single basidium within any of the pore tubes. In some years, even during the rainy seasons when there were intervals of drought, I could get basidia and tramal-hyphae projections with secondary spores side by side within the pore tubes of these Ganoderma species, whereas conversely, when there were unexpected showers of continuous rain for about a week in November, 1931, I found that the tramal-hyphae projections had all disappeared and we had only basidia within their pore tubes. As years pass on, I believe many more will probably be added to

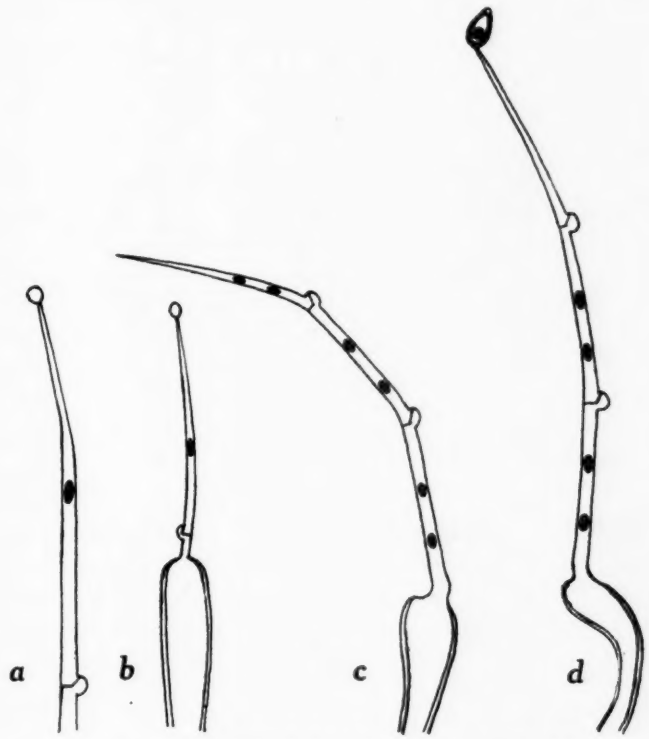

FIG. 1. Types of hyphal projections among basidia.

the list of Polypores that reproduce by such secondary spores after the rains or during the dry intervals of the rainy season.

Fixing hymenial portions of fresh sporophores of *Ganoderma lucidus* and *G. applanatus* with tramal-hyphae projections, bearing secondary spores after the rains, in Bouin's fluid and finally embedding them in paraffin and staining microtome sections (6–10 μ thick) with Heidenhain's iron haematoxylin and gentian-violet (Dorothy Newton's method) it was found that the tramal-hyphae projections are originally binucleate. Then the 2 nuclei in the hyphae gradually fuse into one fusion nucleus, which fragments usually into 4 or 5 pieces (mere black dots). The fragments then pass out of the elongated hyphae into the terminal spore, where the nucleus of the spore seems to be constructed from these chromatin fragments. All these stages have been figured in the accompanying camera-lucida sketches (Fig. 2). No mitotic stages could be traced. So the mode of formation of secondary spores seems to be by way of amitosis.

The amitotic formation of normal tissue is by no means without parallel. Guilliermond (6) has shown that, in the case of yeasts, budding seems to

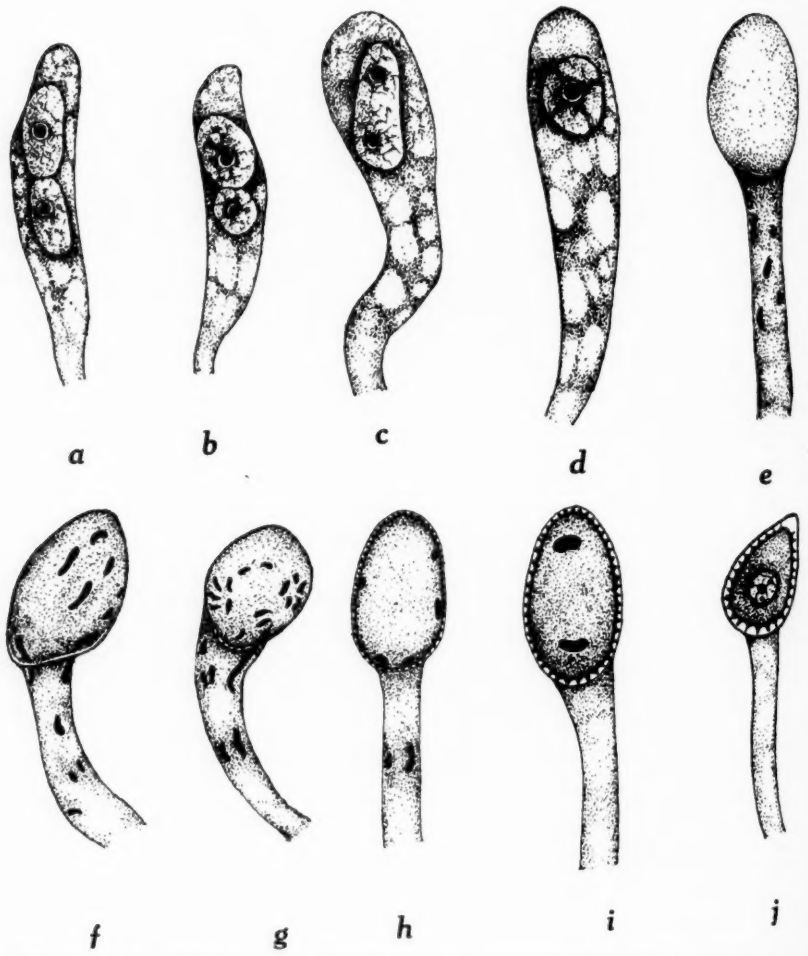

FIG. 2. *a–d.* Tramal hyphae with nuclei. *e–j.* Tramal hyphae with sectioned spores in different planes. Detailed explanation is given in the body of the text. × about 1800.

take place by amitosis. In the case of *Sporobolomyces roseus,* Buller (3, pp. 191–193) has recorded that at the time of spore formation and of the maturity of the spore the nucleus of the yeast cell passes up to the sterigma and there becomes constricted into 2 daughter nuclei evidently by way of amitosis. In the cytologic study of Synchytrium, Griggs (5, pp. 127–138) holds that the division of the primary nucleus is by the process of amitosis. The formation of reproductive cells, independent of mitosis in certain specific cases, must affect the current theories of heredity, which, according to Mendel's law, lean very heavily on the individuality of the chromosomes and their separation in the reduction division. In this connection Griggs

(5) remarks: " . . . It is obvious that our theories of heredity will require considerable revision."

Brefeld (2) regarded the simple conidiophore with few conidia in *Fomes annosus* as the ancestral form of basidium; but, unfortunately, conidiophores had not been investigated cytologically, nor had the mode of formation of conidia from the tips of the conidiophores. Hence, any comparison is not possible. On the other hand, Buller (3) remarks that conidia are all unlike basiodospores, as they are probably not shot away by the drop-excretion method. Hiley (7, p. 105) also is of the opinion that, cytologically, there probably is great distinction between the modes of formation of conidia and basidiospores.

Chamberlain (4) has recently remarked that free nuclear division is a phenomenon arising from the fact that the nucleus present was too small to segment the comparatively large mass of cytoplasm. In connection with growth of protoplasm, Sharp (8) also remarks that a certain proportion of nuclear and cytoplasmic substances (the "nucleo-plasmic ratio") must be maintained. Bergman (1) holds almost the same view that "the nucleo-plasmic coefficient varies with the absolute size of the nucleus."

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PHYTOPATHOLOGICAL NOTES

A Probable Case of Sulphur Starvation in Tobacco.[1]—On August 31, 1934, while examining tobacco in Owen County, Kentucky, a peculiar chlorosis of the tips of the upper first to third leaves of topped White Burley tobacco plants was noticed in several fields, and a few days later the same condition was observed in fields in Nicholas County. The affected leaves were green at the base, but the tips were grayish yellow, the yellowing sometimes extending well down on the edges of the leaves (Fig. 1, A). The areas in which affected plants were found were hilly and subject to considerable erosion. The soil was hard and cracked. Chlorosis was most severe on the slopes, and least on the ridges, but did not occur on newly cleared land or land to which a mixed fertilizer had been applied for the tobacco crop. The growers were familiar with the trouble and claimed that it occurred in years when tobacco made better growth than would be expected from the fertility of the soil and where commercial fertilizers had not been used.

It was evidently a deficiency trouble, and the symptoms very closely resembled those attributed to sulphur deficiency, but were unlike any of the other deficiency troubles we have been able to produce in tobacco in sand and water cultures in the greenhouse. The rainfall record for the summer favored sulphur starvation as the most probable cause of chlorosis. The season was dry following setting and, until about 3 weeks before the observations were made, when there was a very heavy rain in a comparatively short time with a great deal of run-off. The tobacco had made most of its growth since that time. Thus, although there is ordinarily sufficient sulphur carried down with the rain in Kentucky[2] to satisfy crop requirements, the amount carried down by a single heavy rain would be much less than by several lighter rains occurring over a longer period of time. Karraker and Bortner[3] demonstrated that sulphur starvation sometimes develops in tobacco grown in pots in soil from the Central Bluegrass area of Kentucky, if only a small volume of soil be used to which no sulphur-containing fertilizer has been added. Analyses of a large number of soils, made by Shedd,[4] show a much lower percentage of sulphur in subsoils than in sur-

[1] Published by permission of the Director of the Kentucky Agricultural Experiment Station.

[2] Johnson, E. M. Sulfur in rainfall in Kentucky. Jour. Amer. Soc. Agron. 16: 353–358. 1924.

[3] Karraker, P. E., and C. E. Bortner. Studies of frenching of tobacco. Kentucky Agr. Expt. Sta. Bull. 349, 1934, see page 99.

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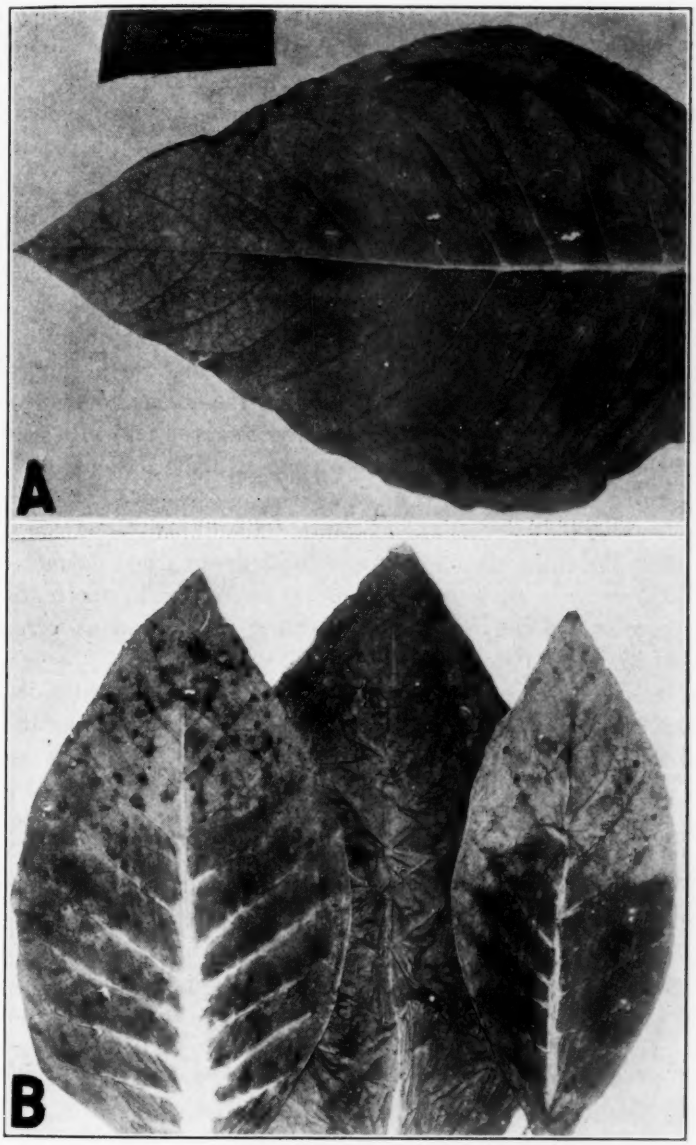

FIG. 1. A. Uncured leaf of white Burley tobacco collected in Owen County, Ky. The chlorotic tip closely resembles sulphur deficiency. A small bit of leaf from a normal green leaf is shown for comparison. B. Two chlorotic leaves from Owen County and a normal leaf (center) from the station farm when nearly cured. The mid and lateral veins of the chlorotic leaves were still partly alive. The areas that were chlorotic before curing show clearly in the cured leaf.

face soils of cultivated areas. The erosion already noted had removed most, if not all, of the original surface soil, as indicated by the clayey nature of the soil where the deficient leaves were found.

Affected leaves from Owen County and normal leaves from the Station farm were brought to the laboratory for observation while curing and for chemical analysis. Some of the affected leaves were cured whole. The chlorotic tips were removed from others, and both the tip and butt portions cured. The chlorotic tips yellowed and died very quickly. Affected whole leaves, however, yellowed very slowly in comparison with normal leaves and dried out much more slowly. In 12 days the normal leaves were completely browned and had been for several days, while the affected leaves and the severed butts of affected leaves were just beginning to brown. After 20 days the midveins of 7 of 10 of the normal leaves were dry, whereas the midveins of 10 affected leaves were green and turgid nearly the length of the leaves. There was also a strip of blade tissue still alive along the basal third of the midveins of some of these leaves (Fig. 1, B).

When cured, the normal leaves became a uniform cinnamon to Kaiser brown, while the chlorotic areas of affected leaves turned chamois to honey yellow (Ridgeway), grading off to cinnamon brown in the more normal-appearing areas. The grower on whose farm the specimens were collected stated that his tip leaves always sold well.

Chemical analyses of the affected tips, butts of the same leaves, and the normal leaves were made by O. M. Shedd, of the Department of Chemistry of the Experiment Station. Nitrogen, nicotine, crude ash, phosphorus, magnesium, potassium, and sulphur (0.42, 0.56, 0.61 per cent sulphur) each increased in the order of chlorotic tips, butts of affected leaves, and normal leaves, the latter being highest. Iron was the same in affected tips and normal leaves but slightly lower in butts of affected leaves. Manganese was highest in the normal leaves (0.0089), next in the affected tips (0.0037), and least in the butts of affected leaves (0.0026 per cent). Calcium was lowest in affected tips. Chlorine was highest (0.52 and 0.49 dup.) in the butts, least in normal leaves (0.10), and intermediate in the affected tips (0.17 per cent). The high chlorine content of the butts of affected leaves may account for their slow curing.—W. D. VALLEAU, Kentucky Agricultural Experiment Station, Lexington.

Nonsterile Soil Leachate Stimulating to Zoosporangia Production by Phytophthora sp.[1]—A copious production of papillate zoosporangia of *Phytophthora cinnamomi* Rands has been obtained consistently from myce-

[1] Published with the approval of the director as Miscellaneous Paper 14 of the Pineapple Experiment Station, University of Hawaii.

lial mats grown for 4 days in malt broth[2] at 25° C.—27° C., subsequently washed in sterile distilled water, and incubated at 21° C.—25° C. in nonsterile soil leachate.

Zoosporangia of this species described by other authors have been in all cases of the nonpapillate type. They are produced only scantily and with difficulty by the methods of Petri,[3] Leonian,[4] and Waterhouse.[5] This difficulty is largely responsible for the erection of the new genus Pseudopythium by Sideris, as a designation for his isolations of *P. cinnamomi*.[6]

Mycelium grown in malt broth is better suited for the production of zoosporangia than that grown in Leonian's succinic acid medium, Waksman's broth, green pineapple fruit decoction, cubes of green pineapple, or on any of the following agars: papaya, malt, corn meal, oats, Ranker's, or Czapek's.

The differences in abundance of sporangia in sterile distilled water, tap water, M/100 KNO_3, dilute malt broth, or sterile soil leachate and that in nonsterile soil leachate have been repeatedly of the order illustrated as concentrations II or III and V respectively by Leonian.[4] The results of experiment CF–31 summarized in table 1 are characteristic of these differences.

The factors in nonsterile soil leachate responsible for stimulation of the production of zoosporangia have not yet been learned, but the results of experiments conducted for that purpose are suggestive.

It was first learned that the failure to add iron to sterilized soil leachate or M/100 KNO_3 was not a limiting factor. The age of mycelium ranging from 72 to 120 hours exerted no measurable influence. Essentially similar quantities of sporangia were formed at 21° C., 25° C., and 29° C. (but none at 35° C.) in the leachates of 3 soils. They were found to occur abundantly only in the nonsterile extracts of these soils, having pH values of 5.9, 6.8, and 7.2 respectively, being most abundant at pH 6.8. Scarcely any were formed in the sterile leachates having pH values of 6.4, 7.3, and 7.6. Copious production of sporangia occurred in all leachates from soils dried at 43° C. for 24 hours and at 27.5° C. for 72 hours. Both combinations of

[2] Mehrlich, F. P. Medium for growth of Pythiaceous fungi. Phytopath. **24**: 1127–1128. 1934.

[3] Petri, L. Ricerche sulla morfologia e biologia della *Blepharospora cambivora*, parasitica del castagno. Atti. R. Accad. Lincei, Rand. Cl. Sci., Mat. e Nat., Ser. 5, 26 (2): 297–299. 1917.

[4] Leonian, L. H. Physiological studies on the genus Phytophthora. Amer. Jour. Bot. **12**: 444–498. 1925.

[5] Waterhouse, G. M. The production of conidia in the genus Phytophthora. Trans. Brit. Mycol. Soc. **15**: 311–321. 1931.

[6] Mehrlich, F. P. *Pseudopythium phytophthoron*, a synonym of *Phytophthora cinnamomi*. Mycologia **24**: 453–454. 1932.

TABLE 1.—*Factors favoring zoosporangial production in strain 60 of Ph. cinnamomi (Sideris' Pseudopythium). Concentrations of sporangia scored according to Leonian's figures (p. 450)*[a]

Nutrient medium[b]	Soil solution		Score for 3 plates
	Sterility	Quantity	
1	sterile	1.5 cc.	9
1	not sterile	1.5	12
1	sterile	3.0	3
1	not sterile	3.0	15
1	sterile	6.0	9
1	not sterile	6.0	15
2	sterile	1.5	6
2	not sterile	1.5	8
2	sterile	3.0	4
2	not sterile	3.0	3
3	sterile	1.5	2
3	not sterile	1.5	9
3	sterile	3.0	0
3	not sterile	3.0	5
3	sterile	6.0	0
3	not sterile	6.0	4

[a] See footnote 4.

[b] Mycelial mats were grown for 96 hours in nutrient medium (1) malt broth, or (2) green pineapple decoction, or (3) Leonian's succinic acid medium. Following washing in sterile distilled water, they were incubated in 100-mm. Petri dishes of soil solution of the quantity and sterility indicated.

time and temperature had previously been shown to kill the Phycomycetes occurring in the soil. No sporangia were found in steam-sterilized leachates of the same soil.

A more intensive study was then made of the effect of different modes of sterilizing the soil prior to leaching or of sterilizing the leachates of nonsterile soil. The method of Pistor[7] for producing bacteriological sterility of soil without markedly affecting solubility of the ash, or changing total acid or pH, MgO nitrogen, total nitrogen, or HCl (Sp. g. 1.19) hydrolizable nitrogen was compared with other methods shown in table 2 using a single soil.

Other species of Phytophthora causing pineapple heart rot also produce sporangia most abundantly in nonsterile soil solution.

From these studies it appears probable that organisms other than Phycomycetes present in nonsterile soil leachate may bring about conditions most favorable for the production of zoosporangia by *Phytophthora* sp.

[7] Pistor, R. Beiträge zur Kenntnis der biologischen Tätigkeit von Pilzen im Waldboden. Centralbl. Bakt. Abt. II, **80**: 378–410. 1930.

TABLE 2.—*The comparative effects of various modes of sterilizing soil leachate on the production of zoosporangia*

Number	Leachate preparation[a] Type	pH	Abundance of zoosporangia
1	Steam sterilize soil, 250° F. for 2 hours, then leach	6.9	None
2	Sterile soil by Pistor's method, then leach	5.9	None
3	Leach unsterilized soil: sterilize leachate, 250° F., 20 minutes, do not aerate	6.7	None
4	Aerate aseptically an aliquot of sterile leachate from treatment 3	4.9	Scant
5	Aliquot of leachate from (3) unsterilized	5.9	Abundant
6	Sterile Petri's[b] mineral solution instead of soil solution	6.2	Scant
7	Inoculate 100 cc. of Petri's solution with 1 cc. aliquot of (5), incubate 24 hours	.....	Abundant

[a] Quadruplicate 100 mm. Petri dishes were aseptically prepared following the treatment in bulk of each leachate.

[b] $Ca(NO_3)_2 \cdot 4H_2O$—0.40 gm.; KH_2PO_4—0.15 gm.; $MgSO_4 \cdot 7H_2O$—0.15 gm.; KCl—0.06 gm.; distilled water—1 liter.

The presence or absence of papillae on the sporangia of *Phytophthora cinnamomi* appears to be a variable character dependent upon environment for expression. It is, therefore, of doubtful taxonomic value.—F. P. MEHRLICH, Pineapple Experiment Station, University of Hawaii, Honolulu, Hawaii.

Gloeosporium Leaf Spot, a Serious Disease of Orchids.—Plants of *Pholidota imbricata* Lindl. growing in the floricultural greenhouses of the University of Illinois were found to be severely infected with a disease of the foliage (Fig. 1, A, B). The disease may originate at many points on the leaf by the germination of scattered conidia of the causal organism, with resultant prominent, sunken, reddish brown spots with a definite margin. These spots eventually coalesce and in many cases destroy the entire leaf, which becomes brown and dry. In several instances it was observed that the disease may originate somewhere near the apex of the leaf and gradually spread backwards towards the pseudobulb, destroying the blade in its entire width as it travels.

Infection may take place on either side of the leaf, as evidenced by the minute specks characteristic of the early stages of the disease. The tissues

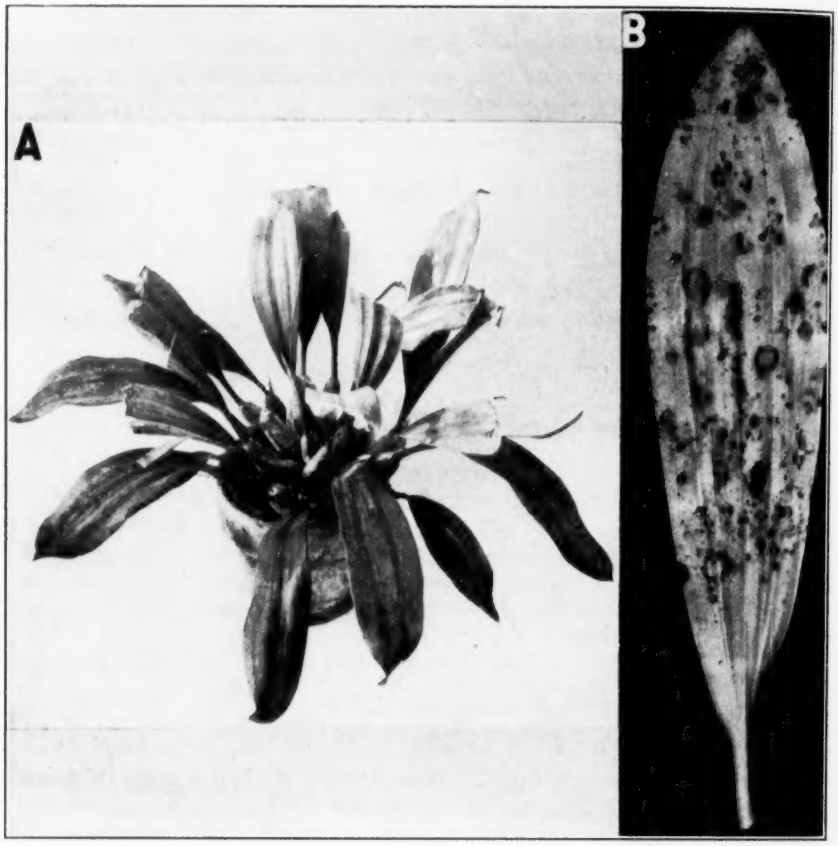

FIG. 1. A. Plant of *Pholidota imbricata*, showing severity of infection with Gloeosporium. Note that the tips of numerous leaves have been removed in an attempt to prevent the further spread of the disease. B. A severely infected leaf of *P. imbricata*, showing spots in different stages of development.

are soon destroyed, however, and the spots become visible on both sides. On reaching a diameter of about 5 mm., a diseased spot assumes in most cases the characteristic appearance of a wide crater with the center depressed and the margin raised above that of the healthy tissues surrounding it. The diseased leaf finally turns brown and dries and the acervuli of the causal organism are evident in great abundance over the surface of the leaf. The crater-like spots above described, characteristic of the disease before the death of the leaf occurs, are still clearly visible even after the entire leaf blade is dead, but the acervuli are not confined to these spots.

The causal organism belongs to the form genus Gloeosporium. Preliminary infection experiments on apple resulted in the production of a

disease the symptoms of which were identical with those of typical bitter rot. The perfect stage of the organism has not been found, however, on the leaves of Pholidota, nor has it yet been induced in culture or on any of the hosts that have proved susceptible to the organism. It is, therefore, impossible to ascertain, as yet, whether this Gloeosporium is the imperfect stage of *Glomerella cingulata*.

Glomerella cingulata and several Gloeosporia have been reported in the literature on various orchids other than Pholidota, but in no case, as far as the writer is aware, have they been reported as causing serious damage. The fact that this disease may assume serious proportions, as in the case with the infected plants at the university greenhouses at Urbana, seemed to justify publishing this preliminary note concerning it. Studies of the causal organism in culture and on a number of susceptible hosts are being undertaken and will be reported later.—CONST. J. ALEXOPOULOS, Department of Botany, University of Illinois.

A New Canker of Hops in Oregon.[1]—An unreported canker of hops was observed in an experimental hop yard in Linn county, near Corvallis, Oregon, on June 19, 1934 (Fig. 1, A, B). Although many yards have been visited during the past 3 years, this abnormality has not been previously observed.

Rarely, leaf petioles, occasionally the tips, commonly the internodes of untrained shoots arising from the crowns of otherwise healthy plants were affected. Almost invariably, the cankers developed at the points of contact of the shoots with the soil, usually under exposure to sunshine but sometimes where shaded. The occurrence of the cankers did not appear to warrant their explanation as due to heat, despite the fact that yards on the sandier soils seemed most affected.

Affected portions of the vines at first develop yellow to light brown discolored areas that usually turn dark brown or almost jet black, involving the entire shoot for a distance of several inches. Particularly during periods of bright, hot days, the lesions often exude drops of clear exudate that soon become darker, more viscid, sometimes coalesce and turn a deep amber color when dry. Cankered areas completely wilt and dry up, causing death of the tip of the shoot beyond the canker.

Instances have been observed in which cankered areas turn light brown or straw color, wilt, and then shrivel without further color changes or development of exudate.

Smears of the exudate to agar slants have, in most instances, developed apparently pure cultures of bacteria.

[1] Published as Technical Paper No. 235, with the approval of the Director of the Oregon Agricultural Experiment Station.

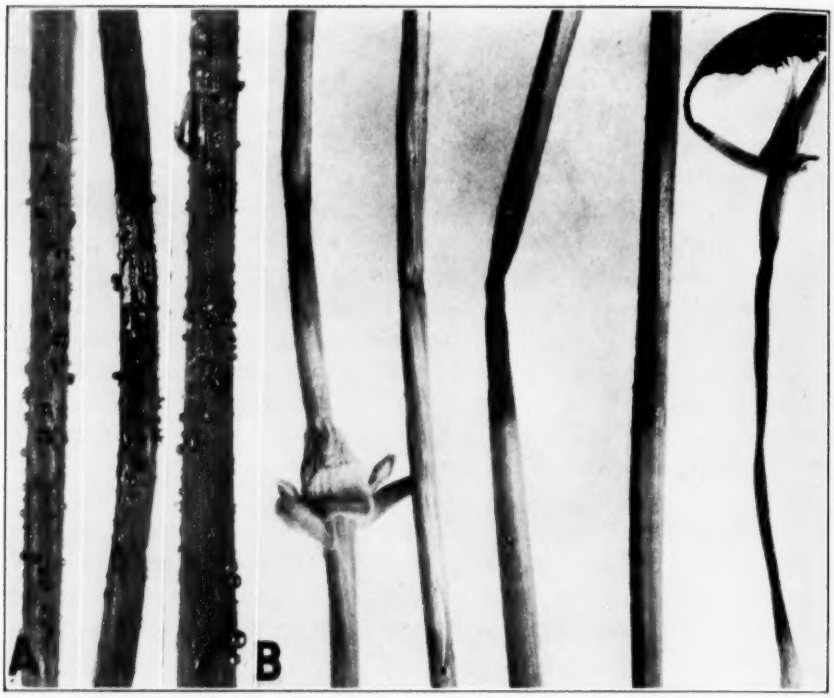

FIG. 1. Various stages in the development of hop canker. A. Drops of exudate containing bacteria. B. Discoloration and atrophy of cankered stems.

Sucking insects that might be responsible for the spread of the disease were not observed on any of the cankered shoots, but feeding scars of the 12-spotted leaf beetle, *Diabrotica soror*, were common in most of the affected plantings but rarely at cankered areas of the stems.

A field survey showed the canker present on the Early Clusters variety in 2 yards in Lane, 1 in Linn, and 3 in Marion counties; on Fuggles in 1 yard each in Marion, Polk and Yamhill counties; on Late Clusters in 1 yard in Benton, 1 in Lane, 4 in Linn, 4 in Polk, and 1 in Yamhill counties; on Red Vines in 1 yard in Linn, 2 in Marion, 2 in Polk, and 1 in Yamhill counties. The latest date on which the canker was found in the field was September 5.

Since early training of vines had been completed before the canker was observed, the economic importance of the injury was slight. Should this trouble appear previous to training, however, the damage to healthy vines might assume commercial significance.

A number of cultures of the bacteria obtained from canker exudate from different yards in various sections of the State are being maintained

in the hope of identifying the organism, conducting cultural studies, effecting artificial inoculations, and making histological examination of dismissed tissues.—G. R. HOERNER and D. C. SMITH,[2] Corvallis, Oregon.

Crown Gall on the Sequoia.—Crown gall on the conifers has only recently been reported in the literature. Brown and Evans[1] found crown gall to be of rare occurrence on *Cupressus arizonica* Green. Miles and Brown[2] list crown gall near the graft union of *Juniperus sabina* L. and Persons[3] reports gall on this same host. Patel,[4] in his agglutination studies, used a culture furnished by the writer from incense cedar, *Libocedrus decurrens* Torr. Muncie and Patel[5] list this same culture in table 7 of their paper. Hansen and Smith[6] studied a white nonmotile rod-like organism causing galls on the Douglas fir, *Pseudotsuga taxifolia* (Lamb.) Britt. The structure of the galls and the characteristics of the organism indicate a different causal organism from *Pseudomonas tumefaciens.*

In the spring of 1934 a culture of *Pseudomonas tumefaciens* isolated from a peach seedling was used in making inoculations on *Sequoia gigantea* (Lindl.) Dec. and *S. sempervirens* (Lamb.) Endl. Fifteen puncture inoculations were made in the open on each of the 2 species during May, June, and August.

One typical gall, $\frac{3}{4}$ of an inch in diameter, was observed on *Sequoia gigantea* in September about 4 months after inoculation; but the gall probably had appeared much earlier than this date. Another smaller hypertrophy, about $\frac{1}{8}$ of an inch in diameter, was observed in October. All the other wounds had healed with no indication of any hypertrophies. Figure 1, B, shows these healed-over wounds above and below the gall.

The inoculations on *Sequoia sempervirens* are negative after 4 months with 2 doubtful inoculations having small enlargements with knot-like outgrowths that may represent the beginnings of galls. The inoculations seem to suggest that sequoias are not immune from but somewhat resistant to

[2] Agents, Division of Drug and Related Plants, Bureau of Plant Industry, United States Department of Agriculture.

[1] Brown, J. G., and M. M. Evans. Crown gall on a conifer. Phytopath. **23**: 97–101. 1933.

[2] U. S. Dept. Agr., Bur. Plant Industry, Pl. Dis. Repr. Sup. 81: 133. 1931.

[3] Persons, T. D. New or unusual diseases reported or observed in Mississippi in recent years. (Abst.) Phytopath. **24**: 843. 1934.

[4] Patel, M. K. Some researches on *Pseudomonas tumefaciens.* (Abst.) Phytopath. **19**: 98–99. 1929.

[5] Muncie, J. H., and M. K. Patel. Studies upon a bacteriophage specific for *Pseudomonas tumefaciens.* Phytopath. **20**: 289–305. 1930.

[6] Hansen, H. N., and Ralph E. Smith. A bacterial gall disease of the Douglas fir. Science, **77**: 628. 1933.

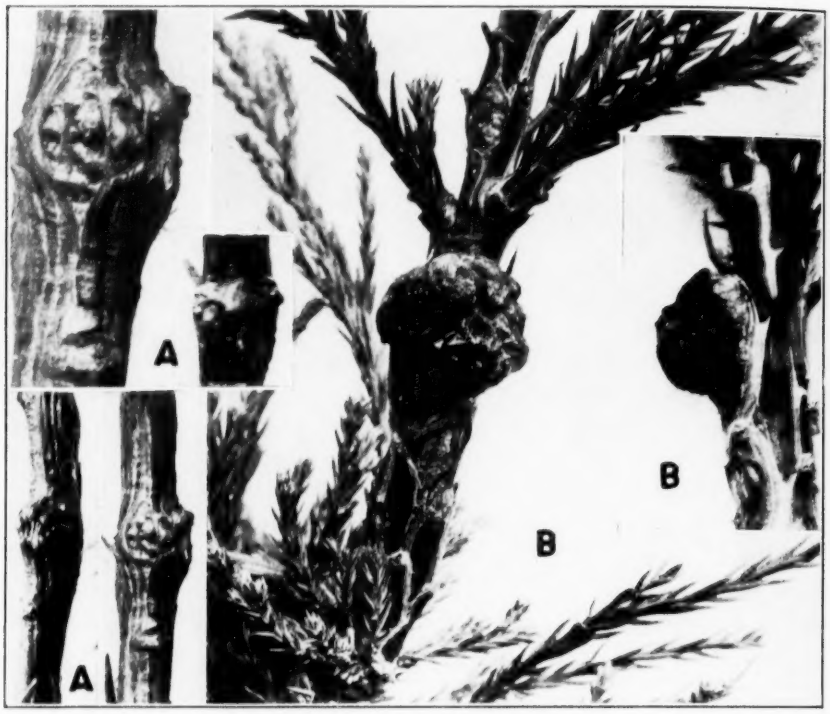

FIG. 1. Artificial inoculation on sequoias. A. Four different views of the same inoculation on redwood, *Sequoia sempervirens*, with a culture of *Pseudomonas tumefaciens* from peach made August 13, 1934, and photographed November 20, 1934. No typical galls have developed, but small knot-like elevations, which may be the initial galls, are present. B. Two views of a gall artificially produced on the big tree, *Sequoia gigantea*. Inoculations made on May 21, 1934, with a culture of *Pseudomonas tumefaciens* from peach. Photographed November 16, 1934. The scars above and below the gall represent inoculation wounds that have healed.

the crown-gall organism from peach. The gall development appears to be slower than that on peach and other deciduous trees.—CLAYTON O. SMITH, University of California, Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

The Growth of Agaricus Campestris on Plots Treated with Sodium Chlorate.—Early in August, 1934, mushrooms (*Agaricus campestris*) were noticed growing on plots that had been treated with sodium chlorate. Part of a field that was covered with quack grass had been laid out in plots 11.5 feet square. Alternate plots were treated with sodium chlorate at the rate of 1.5 pounds to a gallon of water on 100 square feet. This treatment was made on June 1, and was sufficient to kill all of the quack grass and other weeds that were growing on the areas treated.

TABLE 1.—*Mushrooms growing on plots treated with sodium chlorate and on adjoining nontreated plots*

August 3		August 16	
Treated	Nontreated	Treated	Nontreated
7	0	5	6
19	4	15	1
2	5	0	0
4	0	2	0
10	12	4	1
16	3	0	2
27	5	4	0
40	0	5	0
17	0	4	0
13	0	3	1
19	3	7	4
26	1	8	0
21	13	1	1
47	1	8	1
25	0	4	0
Totals 293	47	70	17

Two counts of the mushrooms on treated and nontreated plots were made (Table 1), one on August 3, the other on August 16. Thirty plots were used in each count, giving an area of 1984 square feet of treated soil and the same amount of untreated soil. At the time of the first count there were more than 6 times as many mushrooms on the treated as on the nontreated plots. The second count showed over 4 times as many mushrooms on the treated as on the nontreated plots. Most of the mushrooms on the treated plots were well scattered, whereas on the nontreated plots, most of them were near the sides bordering on the treated areas.

Two questions arose in connection with these observations: Did the mycelium develop in the presence of the sodium chlorate; and why were there so many more mushrooms on the treated plots? When mushroom beds are planted with actively growing mycelial cultures and maintained under favorable growing conditions they do not start producing mushrooms in less than 6 to 10 weeks. Aslander[1] found that there was still some sodium chlorate left in soil 10 weeks after it was applied. Since mushrooms appeared in less than 9 weeks it is obvious that dilute sodium chlorate is not toxic to *Agaricus campestris*. Species of Penicillium, Aspergillus, and Fusarium have been found growing on hay infusion treated with sodium chlorate.

There are several possible explanations for the increased production of

[1] Aslander, Alfred. Experiments on the eradication of Canada thistle, *Cirsium arvense*, with chlorates and other herbicides. Jour. Agr. Res. 36 (11): 915–934. 1928.

mushrooms on the treated areas. The most probable ones being lack of competition and an increase in available food materials. There is another possibility, however, that might be of importance, *i.e.*, a stimulation of growth due to the decomposition of the chlorate. Aslander quotes Alvisi and Orabona[2] as having found that *Penicillium glaucum* Link decomposed potassium and ammonium chlorates.—G. M. SHEAR, Virginia Agricultural Experiment Station, Blacksburg, Va.

Air Currents as a Possible Carrier of Ceratostomella ulmi.—Preliminary experiments indicate that spores of *Ceratostomella ulmi* (Schwarz) Buisman may be dislodged from mycelium or coremia by air currents. In a few tests in which cultures of the fungus were fanned for a few minutes it was found that *C. ulmi* developed subsequently on agar plates exposed for 2 hours at distances of 5 to 40 feet from the source culture.

This experiment was conducted in a tightly closed auditorium 30 × 28 × 14 feet. Sterile agar plates were distributed uniformly throughout the auditorium after which a culture in one end of the room was fanned with a small piece of cardboard for five minutes. The sterile agar plates were exposed for 2 hours and then were incubated at room temperature for 3 days.

Three types of cultures were used, namely (1) a 5-day-old agar culture, (2) a 10-day-old culture on moist elm blocks with a small amount of mycelium and numerous coremia with glistening viscous heads, and (3) a

Date	Type and condition of culture	Source of spores	No. of plates exposed	No. of plates with *C. ulmi* after 3 days' incubation
1/2/35	5-day-old agar plate culture	Mycelium with conidia	60	60
1/22/35	Check	Room air fanned, no culture present	20	0
1/25/35	10-day-old fresh culture on moist elm blocks	Coremia and mycelium with conidia	60	23
1/30/35	Check elm blocks	Room air fanned, no culture present	20	0
2/2/35	24-day-old dried culture on dry elm blocks	Coremia and mycelium with conidia	60	13

[2] Alvisi, U., and M. Orabona. Sul comportamento di percelorati e clorati, nitrati e nitriti in alcuni esperimenti di chimica biologica e sul potere riducente de'Tubercoli radicoli delle Leguminose. Gaz. Chim. Ital. 42 (1): 565–575. 1912.

24-day-old culture on dry elm blocks also showing a small amount of mycelium and numerous coremia whose heads had dried to a gelatinous consistency.

The results of the examination of the exposed plates are given in the tabulation on page 442.

The results indicate that spores of the Dutch elm-disease fungus may be dislodged from fruiting structures on the surface of elm wood if exposed to air currents. Spores from the old dried culture apparently were dislodged less readily than those from the fresh young culture. The check plates exposed in the same room 2–3 days before the cultures were fanned remained sterile. Other experiments indicate that should viable spores lodge in a favorable place, such as in a fresh wound in an elm tree, infection may occur.—S. J. SMUCKER, Forest Pathology, Bureau of Plant Industry and Emergency Conservation Work.

Isolate vs. Isolant.—There seems to be some difference of opinion as to which of these words is preferable for use as a noun to indicate something isolated. Attention is called, therefore, to the fact that the word "isolate," not "isolant," is recognized in the latest edition of Webster's Dictionary in the sense referred to. It is the appropriate Anglicized form derived from *isolatus,* the past participle of *isolare* (= to isolate). "Isolant," on the other hand, would carry an entirely different meaning, being the natural Anglicized present principle form of the same verb. It would convey the transitive meaning isolating (= causing isolation) which, of course, could not rightly refer to an organism that has been isolated.

We have a parallel situation in the use of "precipitant" which the dictionary says means, "that which causes precipitation," and "precipitate" meaning "something that has been precipitated." Similarly, we have "filtrate" (= having been filtered), not "filtrant," and "delegate" (= having been delegated), not "delegant."

Perhaps the confusion in usage arises from an incorrectly assumed analogy to such words as "variant." Here, however, the present participle meaning is clearly appropriate (= that which varies), but in this case, the verb has an intransitive meaning while the verb "isolate" does not.

Preference for the word "isolant" has been based by a recent worker on the avoidance of confusion, by which he doubtless implies that the noun "isolate" might be confused with the verb "isolate." It seems doubtful, however, whether such confusion would often appear. There are many common instances in which the noun and verb are alike, but which we seldom find confusing; for example, the word "delegate" may again be cited along with "fly," "fish," or "fight." In view of the facts presented, it is believed that the apparently growing use of the word "isolant" should be discouraged.—H. P. BARSS, Office of Experiment Stations, U. S. Department of Agriculture, Washington, D. C.

Atanasoff, D. *Virus diseases of plants. A bibliography.* Houdojnik Printing Co., Sofia (Bulgaria), 1934. 219 pp. $3.00.

The author undertook a big task and has done it well. With close to 4,000 titles on a subject relatively so new to modern research methods as are the plant viruses, the omissions must be rare indeed. In fact, the greatest strength and value of the list comes from the inclusion of old or rarely mentioned titles of historical interest. The references are classified mainly on the basis of host plant affected and are further grouped according to plant family. While this arrangement may not be ideal, it is convenient, and its usefulness is enhanced by the addition of a host index as well as an author index. Papers dealing with more general or extensive subjects are listed in two additional introductory sections. The location of abstracts of original articles is also freely given, but no annotations are presented. In general, this compilation will prove invaluable to the virus research workers, especially so, since the author proposes to issue an annual supplement to the present bibliography.—JAMES JOHNSON.

Atanasoff, D. *Bolesti na kulturnitĕ rastenija.* (Diseases of cultivated plants). 626 pp. 221 figs. Imprimerie de la cour. Sofia. 1934.

This is the first college textbook on plant diseases that has appeared thus far in the Bulgarian language. Its most distinguishing features are the scholarly approach adopted in the treatment of the individual topics; the consideration shown for practical control measures as far as these are available; the emphasis on results of field trials; and the intimate treatment of the virus diseases, especially those of the grape and the potato. The book consists of 6 chapters. An introduction is followed by a chapter on each of the following: nonparasitic, bacterial, virus, and fungus diseases and diseases caused by seed plants. The book ends with a Bulgarian and a Latin index. Both in legends and in general text, frequent use is made of Latin names of host or parasite. These, with bibliographic citations, are useful indications to foreign readers as to content and nature of subject matter. The textbook naturally bears evidence of the author's early training in Germany and America and his later sojourn in Holland. The latter is shown by his treatment of the virus problems. His acquaintance with American literature is shown in literature citations and by the influence of the manuals of Heald and Elliott. Possibly, this text may invite increasing attention from neighboring countries because of the proximity of Bulgarian problems and their interpretation in some cases in a familiar language. This may, therefore, be accepted as a textbook notably and worthily broadening the field of influence of modern plant pathology.—S. S. IVANOFF, Department of Plant Pathology, University of Wisconsin, Madison, Wis.

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY
CONSTITUTION[1]

ARTICLE I

This Society shall be known as The American Phytopathological Society.

ARTICLE II

MEMBERSHIP

Sec. 1. The Society shall consist of members, and may include life members and patrons.

Sec. 2. The charter membership of this Society shall consist of the one hundred and thirty persons who accepted the invitation of the Organization Committee of October 25, 1909, to form the Society.

ARTICLE III

QUALIFICATIONS FOR MEMBERSHIP AND DUES

Sec. 1. All persons interested in the study of phytopathology, including the practical control of plant diseases, shall be eligible to membership.

Sec. 2. Any member may become a life member by paying one hundred dollars in ten consecutive annual payments, and any person may become a patron upon the payment of one hundred dollars, and upon election shall have all the privileges of membership.

ARTICLE IV

ELECTION OF MEMBERS

Members may be elected at any regular meeting of the Society or by the Council during the interim. Applications for membership must be endorsed by at least one member of the Society.

ARTICLE V

OFFICERS

The officers of the Society shall consist of a President, Vice-President, Secretary, and Treasurer. Their duties shall be those usually performed by such officers. The President and Vice-President shall serve for one year and the Secretary for three years, or until their successors are elected, and the Council shall fill any vacancies occurring between annual meetings. The Treasurer shall be appointed by the Council for a term of three years and the Council shall fill any vacancy occurring between annual meetings.

The Council shall consist of the President, Vice-President, Secretary, Treasurer, the retiring President, and the Chairman of the Board of Editors of the Journal of the Society, with two members elected one each year, who shall serve for a term of two years, and one member elected annually by each Division. The term of service of a Council member from a Division shall commence at the end of the annual meeting of the Society next following his election by the Division.

All action of the Council or officers must be authorized or approved by the Society.

[1] At the 1934 annual meeting at Pittsburgh, the Secretary was directed to have the constitution of the Society, as revised at that meeting, printed and distributed to the members. The last printing of the constitution was in PHYTOPATHOLOGY, Vol. XX, No. 12, Dec., 1930.

ARTICLE VI

ELECTION OF OFFICERS

The Secretary shall send nomination ballots for officers to each member of the Society in time to allow all nominations to be returned not less than two months before the date of the annual meeting. The Council shall make nominations for any office when such nominations are wanting. The three candidates for each office receiving the highest number of nominating votes shall be placed upon a final ballot, which shall be sent to each member one month before the annual meeting, provided, however, that, if the same person be found to have received sufficient ballots to qualify for nomination to more than one office, his name shall be placed on the final ballot as a candidate only for the highest of these offices as indicated in their order in Article V. Votes shall be mailed to the Secretary and canvassed by the Council. A plurality vote shall elect.

ARTICLE VII

EDITORS, COMMITTEES, AND APPOINTMENTS

The Editors of the official organ of the Society shall be selected by the Council subject to the approval of the Society.

Temporary or standing committees may be appointed at the discretion of the Society.

Unless otherwise directed, the President shall appoint all temporary committees that are to serve during his administration and shall fill all vacancies on standing committees that may occur during his term of office.

ARTICLE VIII

MEETING

An annual meeting shall be held at such a time and place each year as the Council may select, and additional meetings, including special or local meetings, for the presentation of papers, may be arranged by the Council at its discretion.

ARTICLE IX

DIVISIONS

Branch organizations or units within the Society, known as Divisions, may be established on a geographical basis, provided formal application setting forth the reasons for the establishment of the Division is made to, and approved by, the parent Society.

ARTICLE X

AMENDMENTS

This Constitution may be amended at any annual meeting by a three-fourths majority of all the members voting, notice of the proposed amendment having been sent to all the members at least one month previous to the meeting.

STANDING RULES

The rules under which The American Phytopathological Society operates are as follows:

PHYTOPATHOLOGY

1. The official publication of the Society shall be PHYTOPATHOLOGY.
   a. *Officers.* The officers of PHYTOPATHOLOGY shall be an Editor in Chief, term three years; three Editors, terms three years; twelve Associate Editors,

terms three years, four selected each year; Business Manager, term three years; and Advertising Manager, term one year.

b. *Selection of Officers.* The Editor in Chief and the Business Manager shall be selected by the Council and approved by the Society. The Editors and the twelve Associate Editors shall be selected by the Council in consultation with the Editor in Chief and approved by the Society. The Advertising Manager shall be selected by the Council in consultation with the Business Manager and approved by the Society.

c. *Subscriptions, Back Numbers.* Subscriptions to PHYTOPATHOLOGY for institutions and nonmembers shall be $6 per year in the United States and dependencies; Canada $6.25; other countries $6.50. The price of current single numbers shall be 60 cents. The price of back volumes and numbers shall be determined by the business manager with the approval of the Council. Separate copies will not be sold except in cases where the volumes are already broken. Requests to supply lost copies of the journal without charge must be made within sixty days from date of issue.

DUES

2. The annual dues for each regular member, including subscription to PHYTOPATHOLOGY, shall be $5 per year, payable on December 20. The Business Manager of PHYTOPATHOLOGY shall discontinue sending the journal to any members whose dues have not been received by December 20.

PAPERS, ABSTRACTS

3. Members desiring to present papers at the annual meeting must furnish to the Secretary carefully prepared abstracts presenting as clearly and concisely as possible the substance and conclusions of the papers, these abstracts to embody definite results and not to exceed two hundred words in length.

a. *Date Due.* The Secretary is authorized to refuse abstracts received by him after the date on which they are due (Nov. 15). Members are requested not to submit titles or abstracts unless they intend to be present at the meetings.

b. *Number of.* No member shall be permitted to present more than two papers at any one meeting, except by invitation, and, in case of joint authorship, the paper shall be charged to the author presenting it.

c. *Editing of.* All abstracts shall be submitted to an editorial committee of at least three selected by the Editor in Chief of PHYTOPATHOLOGY, and this committee will edit the abstracts in the same manner as original articles published in PHYTOPATHOLOGY.

PROGRAMS

4. The program for the annual meeting shall be in charge of a program committee consisting of the President, Vice-President, and Secretary. To relieve congestion the program committee is authorized to schedule simultaneous sessions when necessary.

DIVISIONS

5. The following provisions shall govern the organization and regulation of Divisions of the Society.

a. *Name of.* Divisions shall use the name of the parent Society with the ap-

propriate geographical term, for example, The American Phytopathological Society, Pacific Division.

b. *Membership.* Divisions shall elect to full membership only members of The American Phytopathological Society, but each Division may elect associate members under such rules as it may adopt.

c. *Publication.* The proceedings of Divisions shall be printed in PHYTOPATHOLOGY. The preliminary abstracts of the Division meetings may, at the discretion of these Divisions, be printed in PHYTOPATHOLOGY under the same rules that govern publication of abstracts of the general Society. This rule, however, shall not be interpreted as limiting the present right of the Editorial Board of PHYTOPATHOLOGY to define the character and amount of any manuscript for publication.

d. *Meetings of.* Whenever The American Phytopathological Society meets within the territory of a Division, the Division shall merge its program with that of the parent society, The scientific sessions of such a meeting shall be presided over alternately by the President of The American Phytopathological Society and the President of the Division. Business sessions may be independent.

e. *Constitution of.* The constitution or articles of organization of all Divisions shall contain a provision or provisions ratifying the above rules. The constitution of all Divisions shall contain nothing in conflict with the constitution of The American Phytopathological Society. With the exceptions defined by the above rules, the Divisions shall enjoy complete autonomy.

6. Unless otherwise ordered, the Secretary and the President, or, in case of his inability to attend, the Vice-President, are authorized to attend the annual meetings of the Society at the Society's expense.

AUDITING COMMITTEE

7. At each annual meeting the President shall appoint an auditing committee to audit the accounts of the Treasurer of the Society and the Business Manager of PHYTOPATHOLOGY.

UNION OF BIOLOGICAL SOCIETIES

8. The Society shall participate in the work of the Union of American Biological Societies and designate its Secretary and Editor in Chief of PHYTOPATHOLOGY as its representatives unless otherwise voted.

BIOLOGICAL ABSTRACTS

9. The Society shall provide for a standing committee of five with terms of five years, one member being chosen each year, to cooperate with the Board of Editors of *Biological Abstracts*.

CROP PROTECTION INSTITUTE

10. Representation on the Board of Governors of the Crop Protection Institute shall be provided for by three trustees, with three-year terms, one selected each year, these trustees to be chosen by the Council.

NATIONAL RESEARCH COUNCIL

11. Representation on the Division of Biology and Agriculture of the National Research Council is provided for in the following way. The various societies represented in the Division are classified into groups. This Society and the Society of American Bacteriologists constitute Group V. This group, as is the case with the others, likewise is entitled to one representative. Each Society shall designate an elector and an alternate for three-year terms. The two electors are to choose the representative on the Division, for Group V, either one of themselves, or a member of one of the societies, the societies being taken in rotation. The term of the representative shall be three years. The elector from the Society not having the representative on the Division in a given period, or some other member whom the Society may select, shall serve as an advisory representative without vote, and without expenses paid by the National Research Council, and may attend divisional meetings to present directly any business of his society.

The elector and alternate of The American Phytopathological Society, terms three years, shall be selected by the Council of the Society and approved by the Society.

OTHER REPRESENTATIVES

12. The following shall be selected by the Council and approved by the Society: two representatives on the Council of American Association for the Advancement of Science for one-year term; one trustee, on the Tropical Plant Research Foundation for a five-year term, and one member of the Editorial Board of the American Journal of Botany for a three-year term.

AMENDMENTS

13. These rules may be amended by a majority vote of the members voting at any regular meeting of the Society.

ANNOUNCEMENT

Members and advertisers are asked to note the new addresses to which all business and other communications relating to the Society and its journal should now be directed:

Secretary—H. P. BARSS, Office of Experiment Stations, U. S. D. A., Washington, D. C.

Treasurer and Business Manager of PHYTOPATHOLOGY—H. H. EDSON, Plant Disease Survey, Bureau of Plant Industry, Washington, D. C.

Advertising Manager of PHYTOPATHOLOGY—R. S. KIRBY, Pennsylvania State College, State College, Pennsylvania.

NOTES AND NOTICES, AMERICAN PHYTOPATHOLOGICAL SOCIETY

A. A. A. S. Entrance Fee Waived. The American Association for the Advancement of Science calls attention to the fact that by reason of the affiliation of our Society any member is privileged to join the Association by paying only the annual dues of $5.00, the usual entrance fee of $5.00 being waived. Apply to the Permanent Secretary, A. A. A. S., Smithsonian Institution, Washington, D. C.

Sixth International Botanical Congress will be held Sept. 2–7, 1935, at Amsterdam. Dr. Johanna Westerdijk, Baarn, Netherlands, is chairman of the Section for Phytopathology.

Any person interested in botany may become a member of the Congress on payment of the subscription of 1250 guilders and will be admitted to all Congress meetings and functions. The preliminary program may be obtained from Dr. M. J. Sirks, Secretary of the Congress, Wageningen, Netherlands.

Any member of the Society expecting to attend this Congress should immediately notify the Secretary of the Society. A good representation is expected.

The International Union of Biological Sciences, it is reported, will meet just prior to the Botanical Congress, to consider amendments to the constitution proposed by the Botanical Section. These would permit the affilia-

tion of individual scientific societies and would clear the way for the Council of this Society to arrange for its adhesion as directed by the Annual Meeting.

Summer Meeting. The Council has authorized the holding of a Summer Meeting of the Society with Dr. E. C. Stakman in charge of arrangements. It will coincide with the Summer Meeting of the A. A. A. S., which is to be held at Minneapolis, June 24–29, 1935. The members will receive further notification regarding program and arrangements.

Former Members may be restored to Active Membership at any time by applying to the Secretary and sending in a check for $5.00 in favor of the Society. All issues of PHYTOPATHOLOGY for the current year will be sent.

H. P. BARSS, *Secretary,*
Office of Experiment Stations,
U. S. Department of Agriculture,
Washington, D. C.

SUMMER MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The summer meeting of The American Phytopathological Society will be held at University Farm, St. Paul, Minnesota, from June 25 to June 27, inclusive. Headquarters will be in Room 107, Plant Pathology Building. Except for one symposium, there will be no formal papers. It is planned to devote considerable time to field trips and round-table discussions at which everyone may express himself as freely as he wishes on any subject related to phytopathology.

Some of the general topics suggested for discussion are as follows:

1. The responsibility of plant pathologists in planning problems of regional or national scope.
2. Regional cooperation on plant pathological problems.
3. Problems in teaching plant pathology to students and to farmers.
4. Improving facilities for publication.

In addition, it is hoped to have discussions on many other topics. The fullest opportunity will be given for exchange of views.

The tentative program is as follows:

June 25—9:00 A. M.

Joint session with Section O of the A. A. A. S., Dairy Science Association, Corn Belt Section of The American Society of Agronomy, American Society of Horticultural Science, Great Plains Section, and The American Society of Plant Physiologists. The general topic will be, "Improving the Germ Plasm of Domestic Plants and Animals." Auditorium of the Administration Building, University Farm.

2:00 P. M.

Symposium, "Past, Present, and Future of Phytopathology in North America." Room 107, Plant Pathology Building, University Farm. To be followed by general discussion.

The evening will be left free for informal round-table discussions or attendance at the general meeting of the A. A. A. S.

June 26—Visits to field plots of the Divisions of Plant Pathology and Botany and Agronomy and Plant Genetics; laboratory and greenhouse exhibits.

In the evening there will be an informal dinner at University Farm, to be followed by round-table discussions.

June 27—Field trips to vegetable plots near the Twin Cities, to the State Fruit Breeding Farm, and to sugar-beet experimental plots at Chaska.

Every effort will be made to provide for the fullest and freest exchange of views. Formality will be dispensed with; the meeting is designed to give everyone opportunity to give and to receive information and ideas.

It is suggested that hotel reservations be made soon, as there is likely to be a fairly large attendance at the A. A. A. S. meetings. Almost any type of accommodation can be obtained at the following Minneapolis hotels:

Name	*Address*	*Without Bath*		*With Bath*	
		Single	*Double*	*Single*	*Double*
Curtis Hotel	10th and 3rd to 4th Ave. S.			$2.00 up	$3.00 up
Nicollet Hotel	Washington and Nicollet	$2.00	$3.50	2.50 up	4.00 up
West Hotel	Hennepin at 5th Street	1.25 up	2.00 up	1.75 up	2.50 up
Andrews Hotel	Hennepin at 4th Street	1.50	2.50	2.25 up	3.25 up
Hotel Vendome	17 S., 4th Street	1.00 up	1.50 up	2.50 up	2.50 up

A list of private rooms near University Farm will be available in Room 107, Plant Pathology Building, in case any members wish to obtain accommodations in private houses.